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SALMON RIVER HABITAT ENHANCEMENT

ANNUAL REPORT - 1989

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PREFACE

This project, No. 83-359, was funded by the Bonneville Power Administration (BPA) under Contract No. DE-A179-84BP1483. The annual report contains three individual subproject papers detailing tribal fisheries work completed during the summer and fall of 1989.

Subproject I contains summaries of evaluation/monitoring efforts associated with the Bear Valley Creek, Idaho enhancement project. Additionally, a final construction completion summary is included as Appendix 1-A.

Subproject II contains an evaluation of the Yankee Fork of the Salmon River habitat enhancement project. This report has been sub-divided into two parts: Part I; Stream Evaluation and Part 2; Pond Series Evaluation. Since construction has been completed on this project, Appendix 2-A highlights major construction events from project inception through completion.

Subproject III concerns the East Fork of the Salmon River, Idaho. This report summarizes the evaluation of the project to date including the 1989 pre-construction evalution conducted within the East. Fork drainage.

ABSTRACT

Bear Valley Creek

Fine sediments from an inactive dredge mine in the headwaters of Bear Valley Creek (BVC) contributed to degradation of spawning and rearing habitat of chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (O. mykiss) in a 55 km section of stream. Major construction efforts targeted at decreasing recruitment of fine sediments in the mined area were completed in the fall of 1988. In 1989 a completed revegetation program has finalized enhancement efforts in the mined area. Biological monitoring for evaluation of project efficacy continued throughout the length of Bear Valley Creek during the summer of 1989. We monitored physical habitat features only in the mined area and the strata directly above and below this area in 1989. Baseline floodplain cover measurements were also initiated this year.

In June, densities of Age 0+ chinook salmon were highly variable according to location and time of year. Age 0+ chinook salmon densities were highest in the mid-portion of BVC at 25 fish/100m^2pool compared to upper BVC where densities ranged from 0.8-8.0 fish/100m^2pool. By late August, however, we documented high chinook salmon densities in upper BVC of 77 to 118 fish/100m^2pool compared to less than 1 fish/100m^2pool in lower BVC.

We found that sloughs play an important role in early season chinook salmon rearing in upper BVC where high flow conditions likely preclude most fish from channel habitat. In early July, we estimated chinook salmon densities of 134 and 59 fish/100m^2 in slough areas of the two upper BVC strata. By August, chinook densities in these sloughs were less than July densities, as well as late season stream densities. Most fish move out of the sloughs by August and this movement may be partially responsible for the high number of chinook observed in upper BVC by late August.

Various physical parameters have responded favorably to the project. The percentage of fine sediments in the mined area has decreased from a high of 34.4% in 1987 to a low of 23.5% in 1989; this difference, however, was not significant. The **stream** area directly below **the** mined section has undergone a similar decrease in fine sediments, from 50.1% in 1987 to 37.9% in 1989. Amount of riparian cover has continually increased since 1984 in the mined area with 1989 measures significantly greater. The mean percentage of vegetative cover ranged from 8.4% in lower floodplain of the mined area (seeded in 1988) to 34.6% in the upper floodplain region (seeded in 1986). The percent cover in the 1586 plot was significantly ($P < 0.05$) greater than cover in the 1988 plot. The grasses Poa pratensis, Agropyron spp. and Phleum pretensis were the primary cover constituents in the three plots.

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INTRODUCTION

Bear Valley Creek (BVC), a major tributary of the Middle Fork of the Salmon River, is a spawning and rearing stream for wild stocks of spring chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (O. mykiss). Redd counts that exceeded one thousand per year in the mid-1950's have decreased to less than 50 per year during the early 1980's (Schwartzberg and Roger 1986). Fish passage problems, ocean and river harvest, and widespread habitat deterioration are among some of the causes which have led to declining adult salmon returns. Treatment of a large, but localized, habitat perturbation was the emphasis of this project.

Placer mining (mid- and late-1950's) near the headwaters of BVC left the stream meandering and downcutting through 2.3 km of unconsolidated overburden. An estimated 500,000 cubic meters of fine material entered the stream since the late 1950's resulting from this floodplain disturbance. This increased sedimentation in Bear Valley Creek caused degradation of the aquatic habitat, not only in the mined area but throughout the length of BVC. Spawning riffles were covered with layers of fine materials while rearing pools filled with sand.

Enhancement efforts were targeted at abating future sediment recruitment. The goal of the project was to virtually eliminate all sediment input from those stream reaches within the mined area contributing the most sediment into Bear Valley Creek. It was estimated that 90% of the sediment problem occurred within four reaches (J. M. Montgomery 1985).

Work on the project began in September 1985 and was completed in early summer of 1989. In the intervening years, implementation and construction occurred during the summer and fall of both 1986 and 1987 and were finished in tne fall of 1988. Revegetation efforts were complete in early summer of 1989 (see Appendix A for a brief final summary of construction activities).

A monitoring and evaluation program established to assess post-treatment effects of enhancement activities on the fish community and physical habitat was initiated during the summer of 1984 and has continued through the summer of 1989. The program is designed to evaluate both the fish community and selected habitat variables. Future monitoring/evaluation programs will continue to evaluate the effectiveness of implementation measures using this baseline information.

STUDY AREA

Bear Valley Creek located in Valley County, Idaho, flows northeast for 54.5 km to its confluence with Marsh Creek to form the Middle Fork of the Salmon River (Figure 1). The stream was sub-divided into seven sampling strata based on physiographic features (Konopacky et al. 1986). BVC is generally a low to medium gradient system (0.2X and 1.52 in strata 5 and 7, respectively) that flows through sub-alpine meadows and lodgepole pine (*Pinus contorta*) forests in a granitic batholith. Alluvial deposits of highly erosive sandy soils typify the region.

METHODS

Stream Habitat

The biological and physical variables measured in 1989 are presented in Table 1. Physical variables were only measured in strata 5, 6, and 7 in August. Since enhancement efforts focused on problems associated with stratum 6, we assumed detectable physical response would first be noticed in that

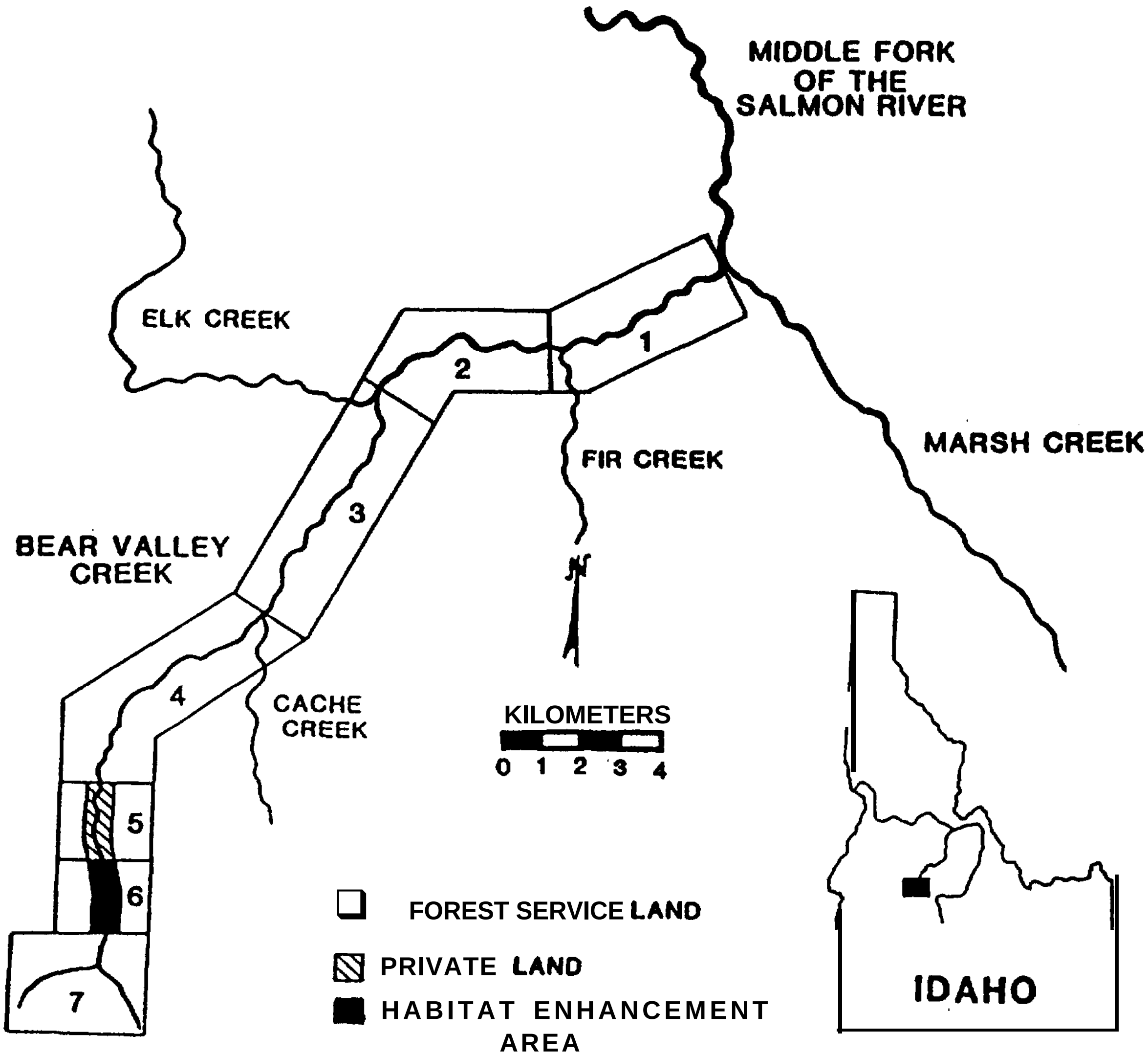

Figure 1. Bear Valley Creek, Idaho, study area and strata location.

Table 1. Physical and biological variables measured in strata 5, 6, and 7 of Bear Valley Creek, Idaho, 1988.

Physical	Biological
Pool Area	Fish
Riffle Area	Species Composition
Pool Width	Relative Abundance
Maximum Pool Depth	Density (River and slough)
Kiparian Cover	Population Size
absolute (cm)	Chinook Salmon Redd Counts
percent of stream width	
Pool Embeddedness	Floodplain
Gradient (%)	Percent Vegetation Cover
Flow (m^3/s)	Species Composition
Riffle Substrate Composition (core analysis)	

stratum and the stratum immediately downstream. because of this, measures and analysis of physical variables were only conducted in the mined area (stratum 6) and the two adjacent strata (strata 5 and 7). Similar physical variables were measured in 1984 and 1485 (Konopacky et al. 1986) and in 1987 and 1988 (Richards and Cernera 1988 and Richards et al. 1989). Statistical comparisons of physical variables were made among strata and year using two-way analysis of variance (2-way ANOVA) and within a strata among years using l-way ANOVA. All tests were run in the software package STATGRAYHICS version 2.6. Variables were measured in one riffle-pool sequence. at seven systematically determined sites in strata 5 and 7, and at 11 sites in stratum 6. Riffle pool sequences and strata delineation were the same as those utilized in 1987 (Richards and Cernera 1988). Surface area and mean width of riffles and pools, maximum pool depth, riparian cover, and stream gradient were measured using methods outlined in Richards and Cernera 1988.

Substrate

Riffle coring methods followed procedures outlined in Richards and Cernera (1988). Two cores within a riffle were collected at each site from strata 5, 6, and 7. Core sampling was the only form of sediment monitoring undertaken in 1989. Due to the high variability of surface particle size distribution measures in previous years, we discontinued that measure this year. We feel that coring data will provide the best indicator of time-trend changes in channel substrate composition. Further in 1990, we will initiate the Burns (1984) sampling method of surface substrate embeddedness which should reduce variation in our embeddedness measures. To compare core particle distribution from each stratum with 1988 samples, we used Chi-square analysis with an alpha level set at G.05 to determine significance, For comparisons of percent silt composition among strata and years and within a Stratum among years, data were arc sin transformed (Dowdy and Wearden 1463) and tested using ANOVA. Prior to 1987, sediment values were based on surface area1 estimates only. To compare estimates among years that involved different sampling methods, we used percentage of sediment less than 85U um in the samples. Since pre-1987 data were based on area1 particle measures and later sampling was based on volumetric measures, area1 estimates probably underestimate volumetric estimates.

Floodplain Monitoring

In 1989, we initiated floodplain monitoring to evaluate the effectiveness of revegetation efforts in stratum 6. Revegetation work began in earnest in 1986. This work included willow planting in the riparian zone and distribution of a wet seed mixture in the adjacent floodplain. Our monitoring Is targeted at assessing the contribution to floodplain cover from post-construction seedings, as well as any natural re-seeding that has occurred.

We partitioned sample areas according to the year that seeding occurred (i.e., 1986, 1987, and 1986). Within each sample unit we established six to seven 100-foot transects along tne floodplain. Transects were set parallel to the stream channel at staggered distances from the water's edge. For each transect we identified plant type to genus and the amount of basal diameter cover provided for every tenth of one foot directly on the transect. From this, we calculated percent cover by vegetation type and total percent vegetation cover. Total percent cover values were arc sin transformed and courparad among treatment areas (by year) using one-way ANOVA.

Fish Distribution

Fish densities were assessed during the third week of June and last week of August in all strata. Observations were conducted by divers equipped with snorkel and mask following the techniques outlined in Platts et al. (1983). All observations were conducted between 1100-1500 hours when visibility was greatest. Density estimates are a combination of fish counts made in pool/glide habitat. In our June session we attempted to enumerate fish in riffle habitat, but due to high flow conditions accurate counts could not be made. These data are not presented. By late August, with flow reductions, most of our sites consisted of both pool and riffle habitat components. Thus, our August density data is probably more representative of actual densities for all habitat types. In years past, density estimates were only documented in pool habitats. Abundance of age 0+ chinook salmon was estimated by using mean and variance values derived from snorkel surveys using techniques outlined in Mendenhall et al. (1979). Individual species densities were compared between sessions and among strata using two-way ANOVA; an alpha level of 0.05 was used to detect significance. When a main effect term was significant, Tukey's multiple range test was applied to discern where the difference occurred. Density data were transformed using a Log base 10 transformation to assure normality prior to statistical analysis (Helwig and Council 1979). Samples of at least 50 fish lengths were collected from each strata during each session.

Redd counts were conducted in late August by ground survey. Individuals were equipped with polarized lenses to increase observer efficiency. The entire length of the stream (except stratum 1) was surveyed for redd abundance and distribution.

Slough Evaluation

In addition to fish sampling in established stream sites, we initiated an evaluation of fish densities in slough areas to document the role of this habitat component to fish production in the system. In each strata (except stratum 1) of BVC we sampled two slough areas during the first week of July and third week of August. Physical measurements of sloughs included area, average depth, and water temperature. Fish densities were estimated using a combination of electroshocking (two-pass) and subsequent seining to allow thorough enumeration. We used a two-sample t-test to compare fish lengths between slough fish from a given stratum to stream fish from the same stratum. Samples from sloughs and stream sites were separated by about a week's time. To compensate for this time difference, lengths of stream fish were adjusted using growth data from stream fish over the summer. We calculated unit of growth per day using 1989 BVC stream fish lengths obtained in the June and August sampling sessions. From this, we adjusted our stream fish samples up during session 1 and down during session 2 to equate with periods of growth experienced by slough fish. During session 1 we did not have enough fish from stratum 5 or 7 stream sites for slough comparisons. In this instance we used fish sampled from stratum 6 stream sites for comparison. Density camparsions were also made using a two-sample t-test. Densities from all sloughs were combined and compared against pooled densities from stream sites for all strata.

RESULTS AND DISCUSSION

Physical Evaluation

The original goal of the project has been met. Contribution of sediment from the four most problem reaches, which accounted for 90% of the sediment imput from the project area (J. M. Montgomery 1985), has been reduced to virtually nothing. Sediment contribution from the other reaches, accounting for 10% of the sediment input, is expected to diminish as the riparian area develops inside the exclosure.

Stream Habitat

The mean and standard error of habitat characteristics measured in 1984, 1987, 1988 and 1989 are presented in Table 2. For every physical habitat variable measured we found a significant difference ($P < 0.05$) among strata but generally not among years and no interaction effect between year and strata (Table 3). Physical habitat in stratum 7 was the most different; however, habitat characteristics between stratum 6 and 5 were also generally characterized by statistical differences (Tukey multiple range test). This confirms the physical differences among stream reaches that initially justified strata selection. Because of these differences it is difficult to use measures taken in strata 7 as controls relative to measures taken in Strata b, the treated area. Therefore, we feel that the best indicator of physical habitat change is the comparison of a variable within a stratum over time.

Stratum 6 at this time continues to show similarities to both strata 5 and 7 in relation to pool cover and depth. Both absolute pool cover and percent pool cover were less in stratum 6 (7.3%) compared to strata 5 (9.9%)

Table 2. Mean and standard error (parentheses) for physical variables monitored in 1984, 87, 88, and 89 for strata 5, 6, and 7 of Bear Valley Creek.

VAKIABLE	STRATUM	1984	1987	1988	1989
Pool area (m^2)	5	147.4 (45.7)	133.5 (17.8)	106.3 (23.6)	123.3 (19.1)
	6	105.0 (13.6)	119.6 (19.6)	68.1 (13.9)	98.1 (13.1)
	7	40.7 (11.2)	43.3 (16.3)	31.8 (13.8)	46.2 (18.5)
Riffle area (m^2)	5	55.0 (16.0)	27.7 (6.6)	25.5 (4.7)	26.1 (6.3)
	6	88.0 (17.2)	126.8 (33.6)	122.2 (37.9)	Y9.3 (33.3)
	7	5.6 (0.8)	8.7 (2.2)	Y.9 (2.9)	15.6 (4.3)
Pool width (m)	5	5.8 (0.3)	5.4 (0.3)	5.1 (0.3)	5.7 (0.23
	6	5.6 (0.2)	5.2 (0.3)	5.3 (0.3)	5.6 (0.3)
	7	2.7 (0.4)	2.9 (0.5)	2.6 (0.5)	2.7 (0.5)
Pool cover (cm)	5	40.0 (7.6)	41.5 (5.5)	35.4 (6.1)	55.2 (8.7)
	6	16.0 (4.1)	24.8 (8.3)	28.8 (9.7)	39.8 (12.8)
	7	87.0 (10.3)	72.9 (9.4)	88.5 (15.6)	70.6 (12.8)
Pool cover (%)	5	9.9 (1.8)	9.0 (1.2)	7.1 (1.3)	9.9 (1.7)
	6	6.8 (2.6)	6.0 (2.3)	6.0 (2.3)	7.3 (2.5)
	7	43.8 (10.0)	37.1 (7.7)	40.6 (11.5)	35.8 (9.7)
Pool depth maximum (cm)	5	99.0 (5.3)	82.0 (6.7)	79.0 (7.9)	106.7 (6.9)
	6	60.0 (9.2)	46.0 (8.6)	46.3 (10.3)	47.9 (9.6)
	7	43.4 (4.7)	48.1 (9.2)	45.4 (9.6)	44.9 (6.5)
Pool embedd. (%)	5	84.2 (9.1)	92.2 (2.4)	95.0 (2.4)	96.3 (0.6)
	6	58.7 (9.7)	52.9 (11.5)	61.4 (11.3)	70.7 (7.4)
	7	12.1 (2.4)	13.1 (3.6)	22.9 (5.2)	41.4 (5.9)

Table 3. Two-way analysis of variance (ANOVA) comparing physical variables (log-transformed) among years (1984, 1987, 1988, and 1989) and strata (5, 6, and 7), Bear Valley Creek, 1989. Independent variables were strata and year; the dependent variable was each physical habitat measure. The alpha level was set at 0.05 and a significant difference is noted by an asterisk.

VARIABLE	SOURCE	DF	F VALUE
Pool area (m')	Year	3	2.05
	Stratum	2	32.86 *
	Year * Stratum	6	0.14
Riffle area (m^2)	Year	3	0.24
	Stratum	2	59.10 *
	Year * Stratum	6	1.30
Pool width (m)	Year	3	0.39
	Stratum	2	71.29 *
	Year * Stratum	6	0.17
Pool cover (X)	Year	3	0.28
	Stratum	2	49.72 *
	Year * Stratum	6	0.20
Pool max.depth (cm)	Year	3	0.82
	Stratum	2	29.56 *
	Year * Stratum	6	0.33
Pool embeddedness	Year	3	1.50
	Stratum	2	1.8.74 *
	Year * Stratum	6	2.50

and 7 (39.83) with amounts in stratum 7 being significantly greater (Figure 2). This result is to be expected as, unlike stratum 7, both strata 5 and 6 occur in meadow type areas of Bear Valley. However, as in 1988, pool depths in 1989 were greatest in stratum 5 compared to strata 6 and 7 (Figure 3). The deep pools in stratum 5 are characteristic of stable, low gradient meadow streams. Similar t.o stratum 7, stratum 6, at this time is higher gradient and characterized by smaller, shallower pools. Pool development is expected to increase as the channel continues to meander and the floodplain stabilizes.

Little change has been noted in terms of pool parameters in stratum 6 over the last five years. Only the amount of pool cover (absolute) was found to differ significantly as the amount of cover in the pre-treatment year (1984) was less than 1987-1989 cover values (Figure 2a). Since 1984, the amount of pool cover has increased each year; the trend towards more pool cover over time indicates that stream riparian conditions have been improving since the pre-construction condition. This trend, however, is not apparent in percent pool cover (relative to stream width) or maximum pool depth (Figure 2b and 3, respectively).

Substrate Analysis

Pool embeddedness has increased in strata 5, 6, and 7 since 1987, however, not significantly (Figure 4). In 1989, the percent pool substrate covered with fines ranged from 41X in stratum 7 to 96% in stratum 5 (immediately downstream of the mined area). Embeddedness was significantly greater in stratum 5 compared to strata 6 and 7 (Figure 4). Pool embeddedness in stratum 5 has increased from 84% in 1984 to 96% in 1989. The cause of this increase in pool surface substrate embeddedness is unclear. However, since a similar trend exists for strata 5, 6, and 7, the increase probably is not due to a localized effect.

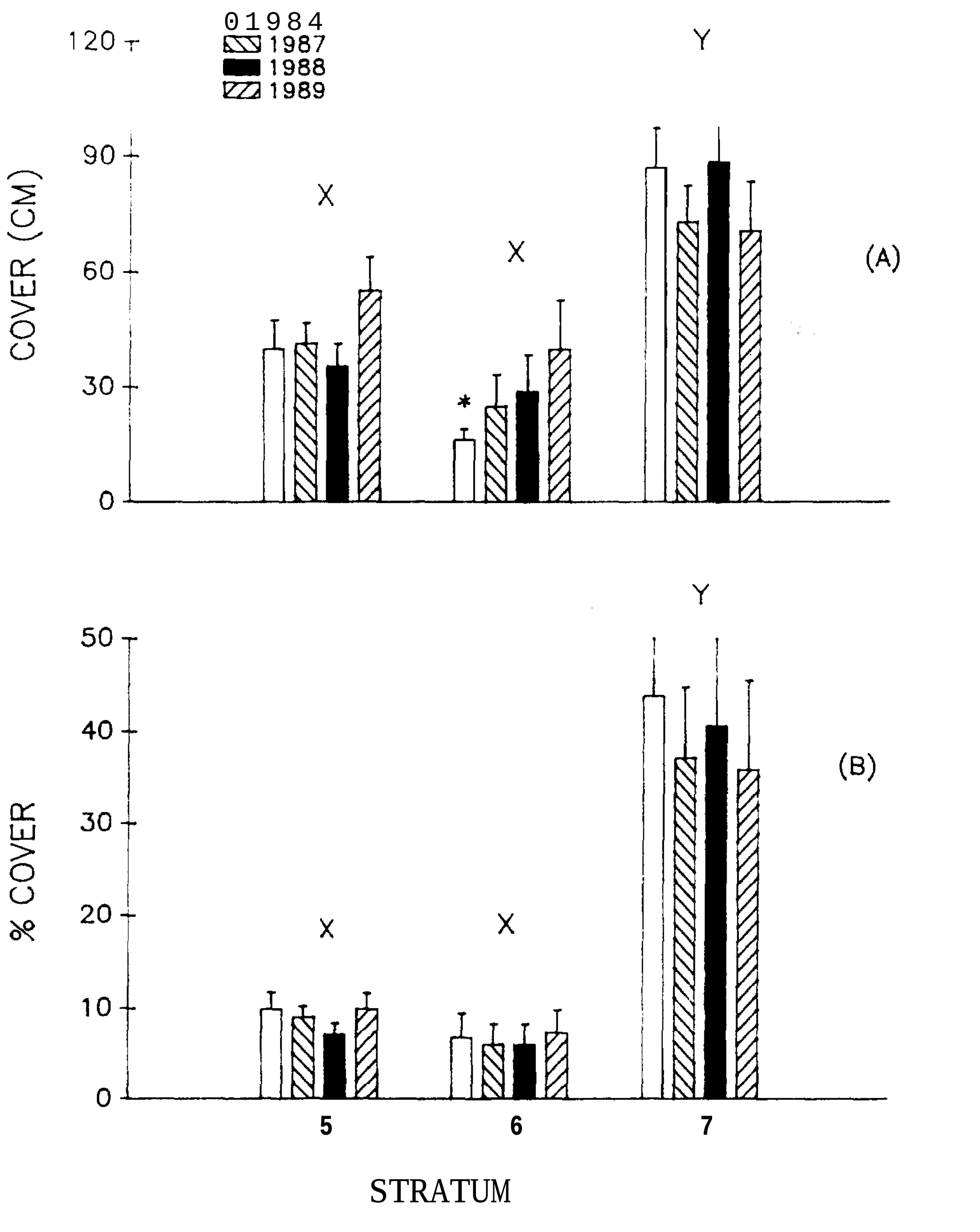

Figure 2. Absolute (A) mean percent (B) pool cover found in strata 5 (n=7), 6 (n-11) and 7 (n=7) among years (1984, 1987, 1988 and 1989), Bear Valley Creek. A common letter indicates no significant ($P < 0.05$) difference between strata with that letter. An asterisk indicates a significant difference from other means within a stratum. Error bars represent 95% confidence intervals of the mean.

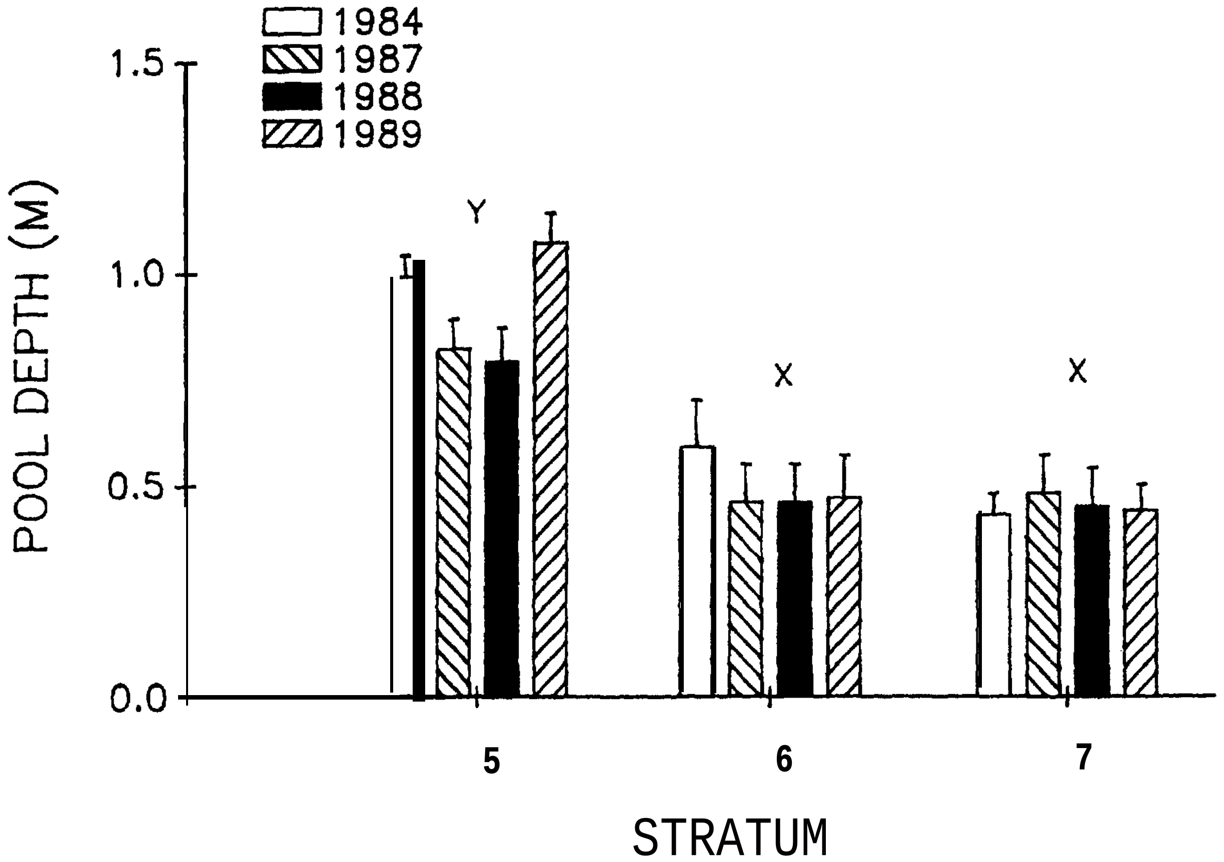

Figure 3. Mean maximum pool depth8 among years and strata **(n=7** for strata 5 and 7 and **n=11** for stratum 6) in Bear Valley Creek. A common letter Indicates no significant **(P<** 0.05) difference between means with that letter. Error bars represent 95% confidence intervals of the mean.

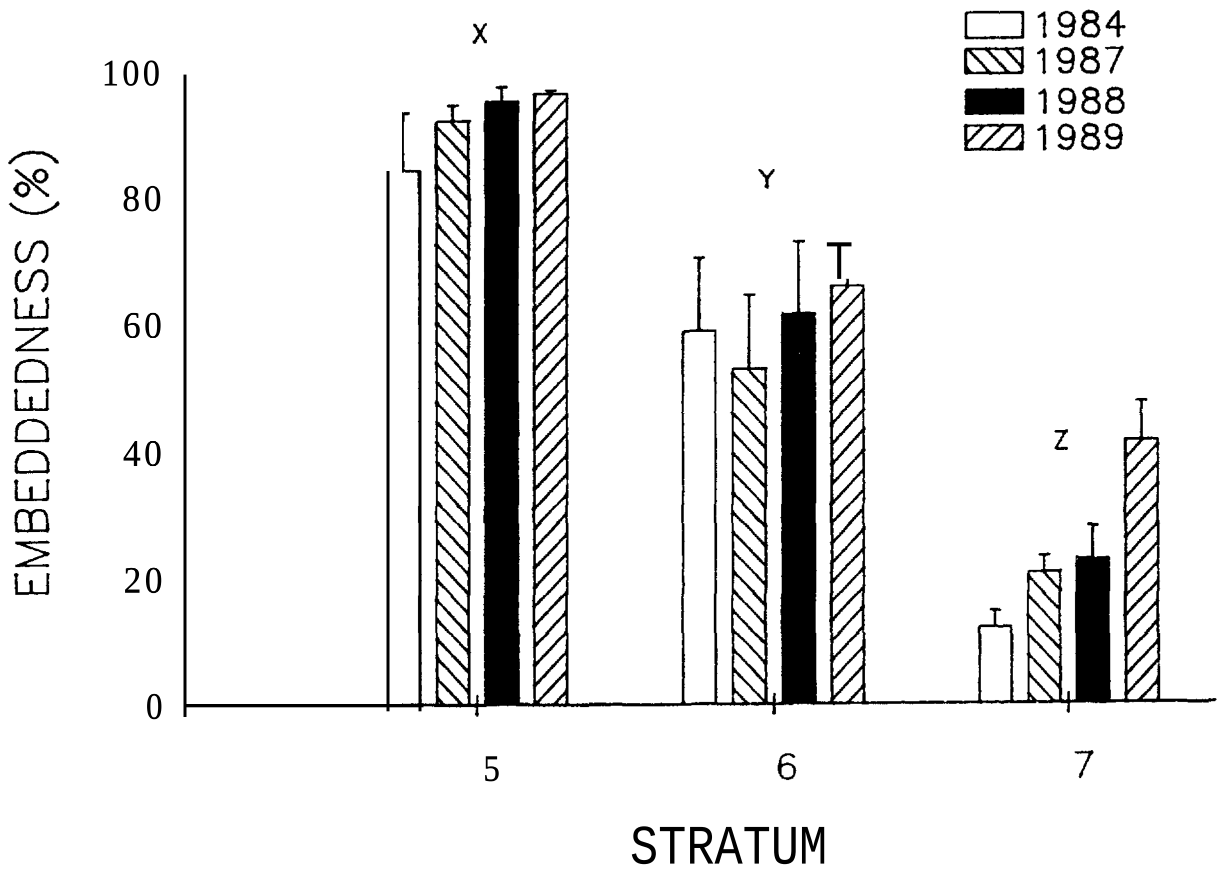

Figure 4. Mean percent of pool substrate embeddedness for strata 5 **(n=7),** 6 **(n=11),** and 7 **(n=7)** among years (1984, 1987, 1988 and 1989) in Bear Valley Creek. A common letter indicates no significant **(P<** 0.05) difference between means with that letter. Error bars represent 95% confidence interval5 of the mean.

Significant differences for particle size distribution between 1988 and 1989 were found in strata 5 and 7, but not stratum 6 . Most of this variation was accounted for in the larger size classes (Figure 5); although in stratum 5 the percent of 0.15 mm fines and smaller in 1989 was only half (10%) of the 1988 level. When the percent fines from core samples (the two smallest size classes, 0.15 and 0.85 mm) were compared, we found a significant difference among strata (5, 6, and 7) but not among years within a stratum (Table 4, Figure 6). Percent fines in stratum 6 were nearly identical between 1988 and 1989 (24%) but down 10% from 1987 levels. Further, percent fines in stratum 5 have decreased since 1987, from 50% to 38% in 1989 (Figure 6). These trends in decreased amounts of sub-surface fines, despite no significant difference, indicate that substrate conditions are improving in and around the mined area.

Core data results differ considerably from our surface embeddedness measures. A similar discrepancy was documented by Richards et al. (1989). They found that surface fines accumulation (using Whitlock-Vibert boxes) was not related to amounts of similar size classes of sediment from sub-surface core samples. Richards et al. (1989) also reported that the amount of sediment that moves and accumulates below the streambed surface (sub-surface Whitlock-Vibert boxes), which can potentially impact a salmon redd, is directly related to the amount of fines found in core samples. Because of this relationship we feel core data is the best indicator of sediment conditions that affect salmon during early life history stages.

Floodplain Evaluation

Mean percent vegetative cover differed significantly (P 0.05) among plots seeded in different years (Table 5). Percent total cover was greatest in the 1986 plot (34.6%) and lowest in the plot seeded in 1988 (8.4%). The majority of the percent relative cover from all three plots was comprised of

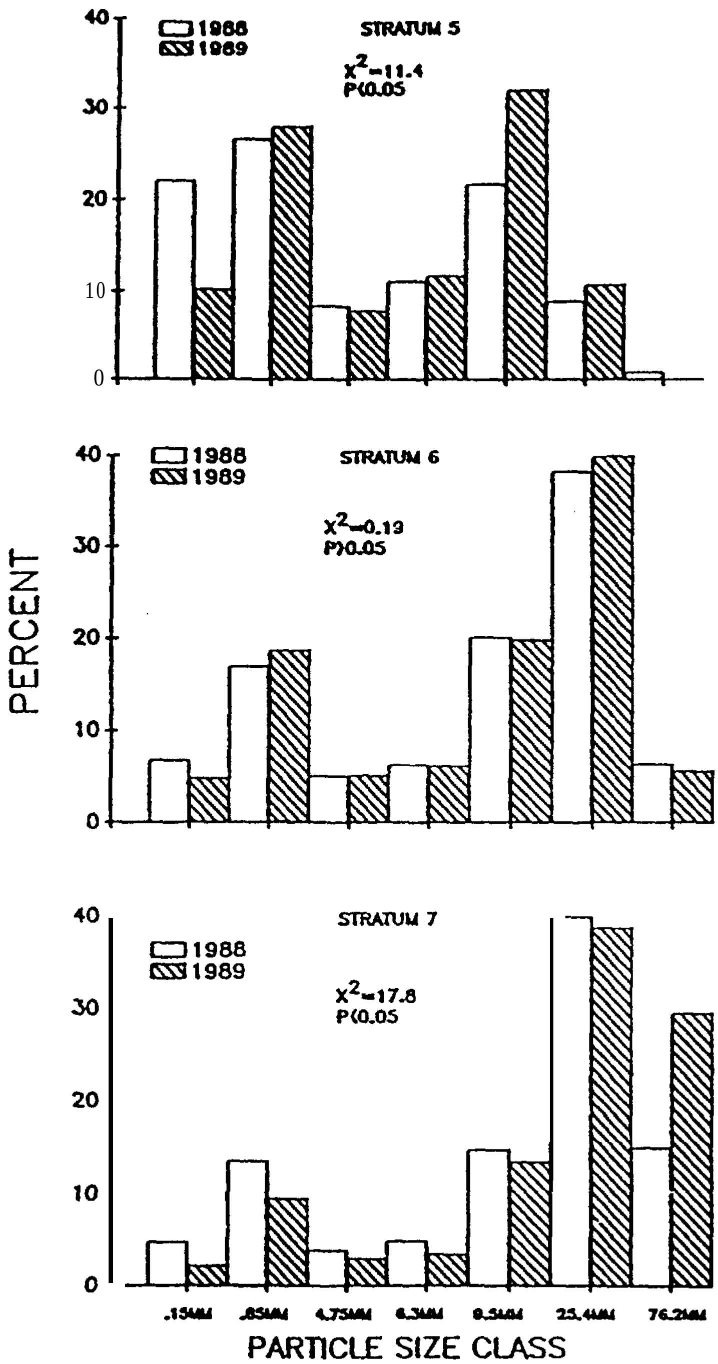

Figure 5. Core substrate particle **size** distributions for strata 5 (n-7), 6 (n-11). and 7 (n-7) of Bear Valley Creek in 1988 and 1989. A probability< 0.05 indicates a difference **in** particle **size** distribution **in** a **stratum between** years.

Table 4. Summary of One-way analysis of variance (ANOVA) using arc sin transformed values of percent fines (0.15 and 0.85 mm size classes combined) in core samples for strata 5, 6, and 7 of Bear Valley Creek. The years 1984, 1987, 1988, and 1989 were the non-metric independent variables. An asterisk denotes significant difference among years at an alpha level of 0.05.

VARIABLE	SOURCE	D.F	MEAN SQUARE	F-RATIO
Stratum 5 fines	Between	3	146.85	2.17
	Within	22	67.57	
Stratum 6 fines	Between	3	112.30	2.11
	Within	35	53.13	
Stratum 7 fines	Between	3	163.89	8.23 *
	'Within	24	19.92	

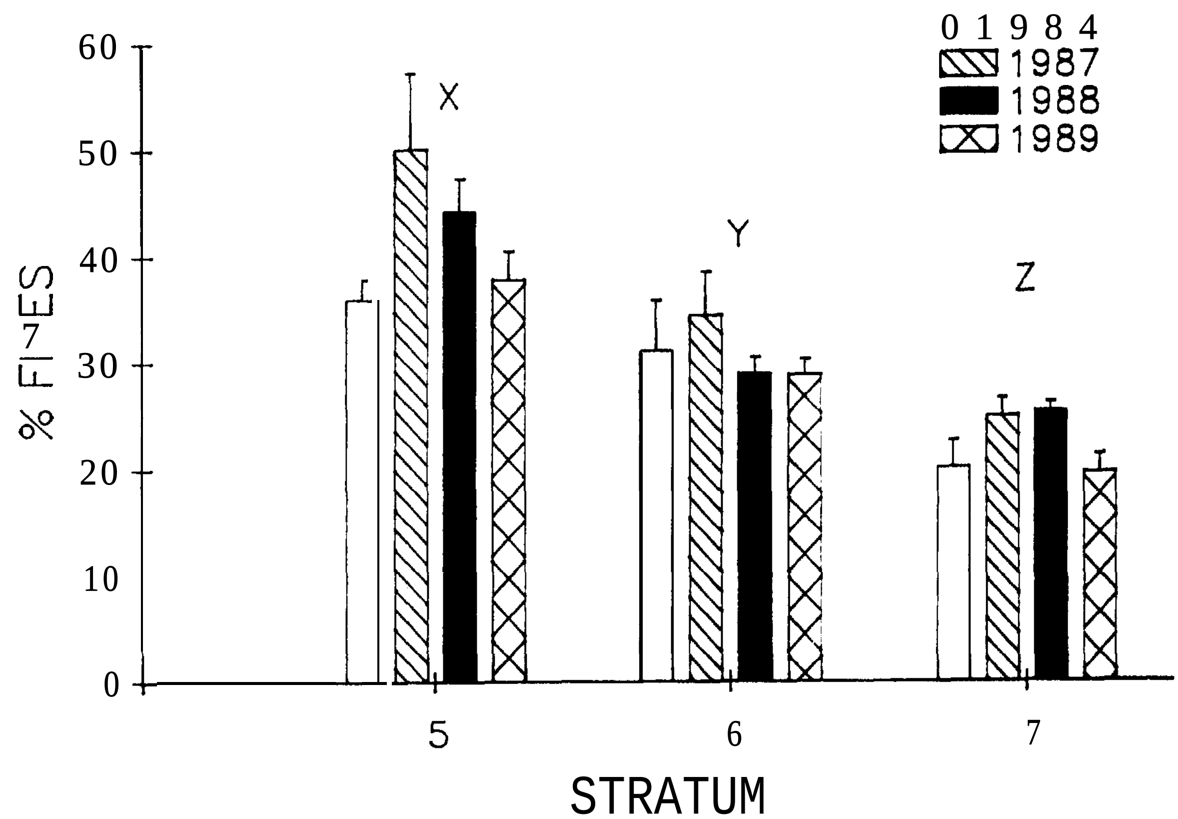

Figure 6. Percent fines (0.15 mm and 0.85 mm size classes combined) found in core samples taken in strata 5 (n-7), 6 (n-11) and 7 (n-7) of Bear Valley Creek from 1984, 1987, 1988 and 1989. A common letter indicates no difference (Pc 0.05) between means with that letter. Error bars represent 95% **confidence** intervals of the mean.

Table 5. Relative percent cover by plant type and mean percent and standard error of the total cover for sections of stratum 6 seeded during three different summers - 1986 (n=7), 1987 (n=6), and 1988 (n=6), in Bear Valley Creek, 1989.

	Cover by Year		
Species	1986	1987	1988
Poa pratensis	64.1	73.9	12.9
Agropyron spp.	20.3	0.8	22.6
Salix scrouleriana	8.2		0.4
Phleum pratensis	5.5	11.1	38.2
Achillea millefolium	0.5	2.5	
Yenstemon globosus	0.4	1.5	
Carex aquatilis	0.3		
Arabis drummendii		0.7	3.2
Descaramia spp.	0.5	0.9	3.6
Muhlenbergia spp.	0.1		
Circium spp.	0.1		
Bromus inermis		2.4	10.1
Bromus tecntorum			3.4
Dactylis glomerata		5.2	5.7
Frageria virginiania		0.1	
Trifolium hybridum		0.9	
% Total Cover	34.6 (6.5)	26.5 (4.6)	8.4 (3.3)

grass species (Table 5). In the 1986 plot, Poa pratensis and Agropyron spp. constituted 84.4% of the measured cover; Poa pratensis and Phleum pratensis constituted 85% of the cover in the 1987 plot; Agropyron spp. and Phleum pratensis constituted 60.8% of the cover in the 1988 plot. Our data show a trend of increasing floodplain cover condition with time. It is unclear whether the 1988 seeded area (lower most portion of stratum 6) will improve as rapidly as the 1486 plot. This lower floodplain area is wider than upstream areas and tends not to retain moisture as well as upper stratum 6, where there are several permanent seep areas. However, if normal precipitation years follow, we should see vegetative cover continue to increase from the 8.4% observed this year in the 1988 seed plot. We have no indication of cover improvement relative to a control since all of stratum 6 was essentially disturbed by the construction effort. However, in 1990 we will measure cover in the lower end of stratum 7 and the upper end of stratum 5 to use as an indicator of the relative degree of vegetation recovery in stratum 6.

Physical Habitat Summary

Similar trends in the physical state of upper BVC continued in 1989, the first year of post construction monitoring, compared to 1988. In the mined area (stratum 6) the amount of fine sediments observed in core samples was lower than pre-treatment conditions and appears to have stabilized. In stratum 5, below the mined area, levels of fine sediments in core samples have continued to decrease since 1987. Fine sediment levels in stratum 7 continued to indicate relatively undisturbed conditions with annual fluctuations attributed to sampling error. Since we feel that core data is the best indicator of critical sediment levels, we intend to increase our core sample size to further reduce sampling variation. Stratum 6 streamside riparian cover has continued to increase since 1984 levels. Cover levels in stratum 6, however, were lower than those observed in stratum 7 and 5. Within the mined area, floodplain cover was greatest (35%) in the section seeded during 1986 compared to mean cover values of 27% and 8% in 1987 and 1988 seed plots, respectively. From this trend, we predict that floodplain cover will continue to Increase in the next several years. This should facilitate channel stabilization and further reduce sediment inputs in the mined area.

Fish Evaluation

Densities

In 1989, age 0+ chinook salmon and older whitefish densities were significantly different among strata while densities of age 0+ chinook salmon and whitefish young-of-the-year differed between sessions (Table 6). Similar to 1988 (Richards et al. 1989) mean total fish densities were low; 0.1-3.4 fish/100m^{2}pool during session 1 and 0.5-20.0 fish/100m^{2}pool during session 2 (Figure 7). Total fish densities were greatest in lower river strata (2 and 3) in June and then in the upper four strata by late August. This shift in fish distribution between early and late summer was also documented in 1988 (Richards et al. 1989). Fish densities by species, stratum, and session are presented in Appendix B.

Age Ot Chinook Salmon. We found a significant difference in age 0+ chinook salmon density between sampling periods when strata were combined (Table 6). We also founa that within a sampling period densities among strata were significantly different (Figure 8). In June, the highest chinook salmon density was observed in stratum 3 (24.8 fish/100m^{2}pool). Similar to 1988 this was in the vicinity of the greatest concentration of counted redcis from the previous year (Richards et al. 1989). By late August, most chinook salmon had

Table 6. Two-way analysis of variance for fish densities (log transformed) by species comparing densities among strata and between sessions (June and August) Bear Valley Creek, 1989. An asterisk next to a probability value denotes significance at the $P < 0.05$ level.

SPECIES BY AGE CLASS	SOURCE	DF	F VALUE	PROBABILITY
	Stratum	6	4.7	0.00 *
Age 0+ Chinook	Session	1	14.3	0.00 *
	Stratum * Session	6	6.0	0.00 *
	Stratum	6	0.6	0.70
Age 0+ Steelhead	Session	1	2.7	0.10
	Stratum * Session	6	0.6	0.70
	Stratum	6	1.5	0.19
Age 0+ Whitefish	Session	1	9.0	0.00 *
	Stratum * Session	6	2.1	0.06
	Stratum	6	4.0	0.00 *
Age 1+ and Older Whitefish	Session	1	3.4	0.07
	Stratum * Session	6	0.8	0.56

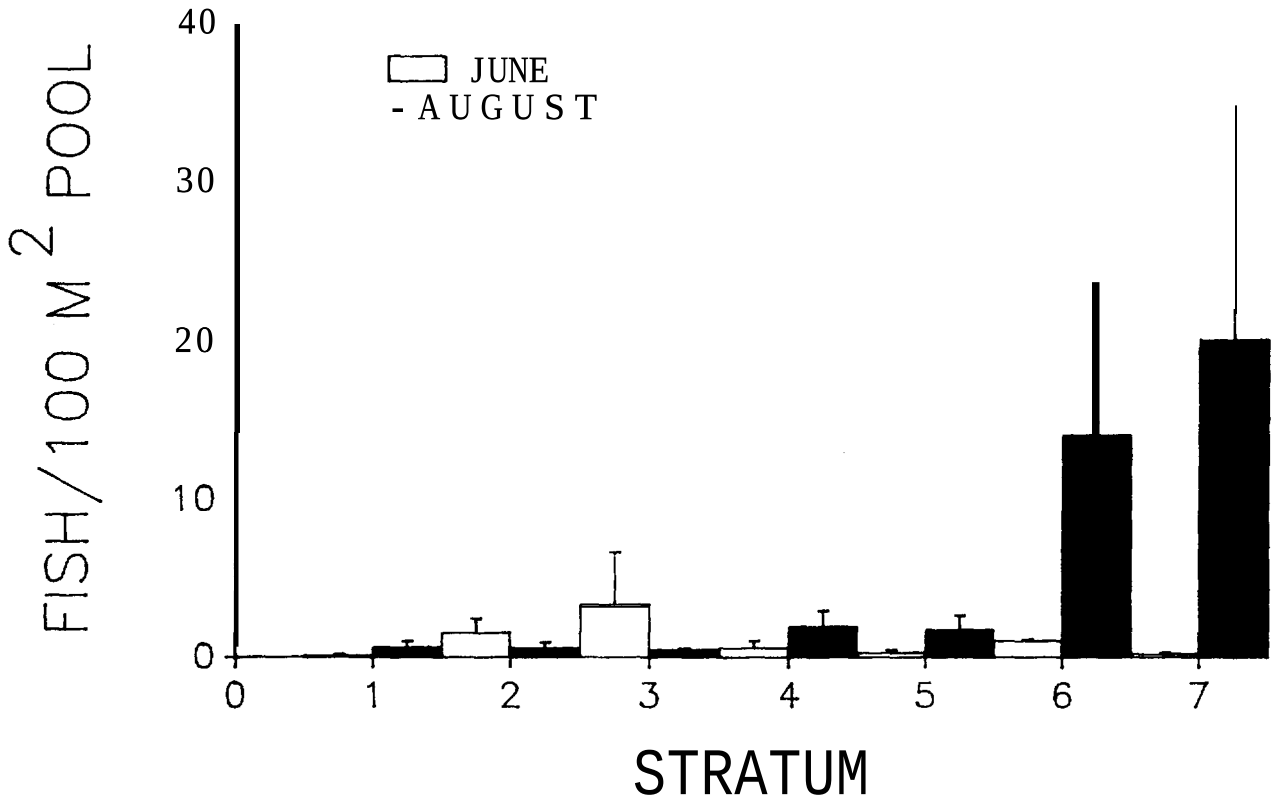

Figure 7. Total fish density by stratum (n=7 per stratum) for June and August in Bear Valley Creek, 1989. Error bars represent 95% confidence intervals of the mean.

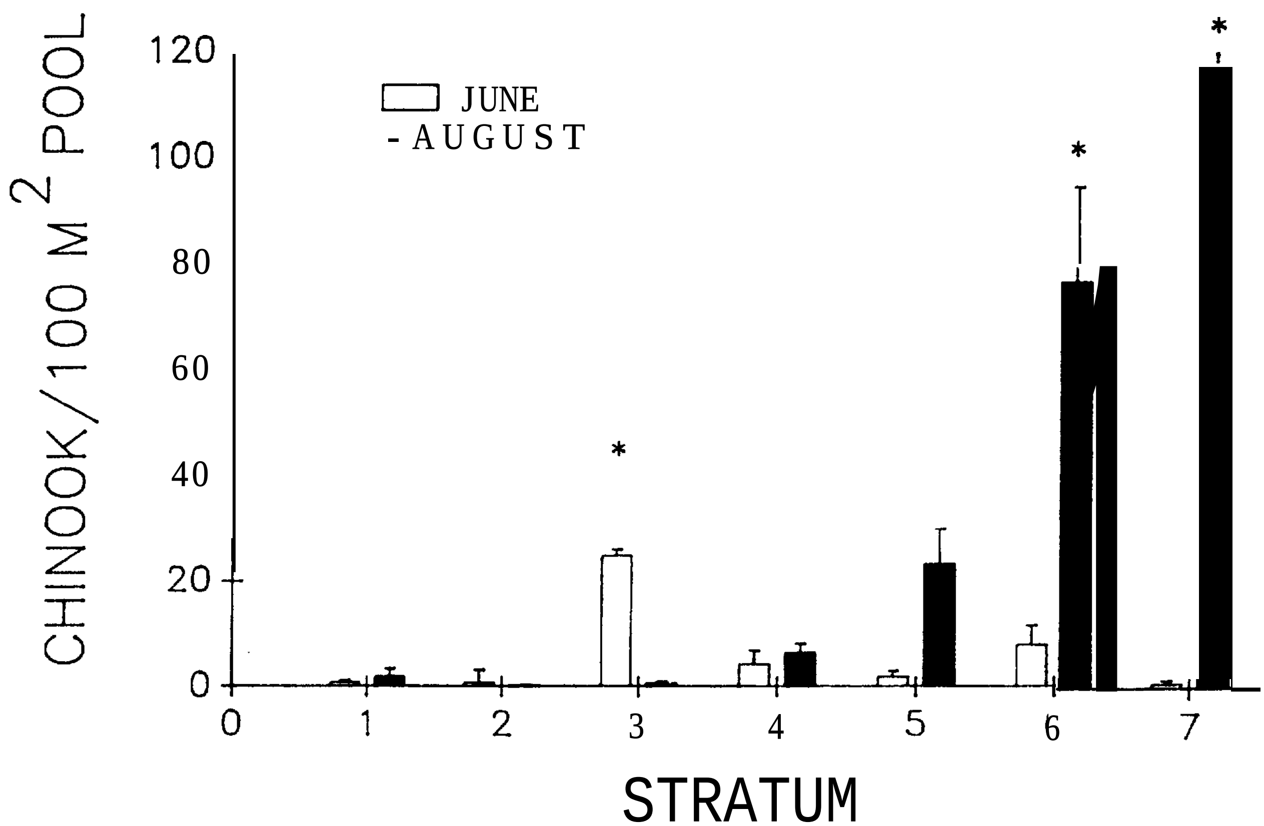

Figure 8. Density of age 0+ chinook salmon among strata (n=7 per stratum) for June and August sampling sessions, Bear Valley Creek, 1989. An asterisk indicates a significant difference ($P < 0.05$) from all other means within a session that do not have an asterisk. Error bars represent 95% confidence interval of the mean.

moved out of the lower strata (1-3) as densities were much greater in the mined area (stratum 6) and above (stratum 7), 76.9 and 117.8 fish/100m^{2}pool, respectively (Figure 8). Even though densities were greatest in stratum 7, variation about this mean density was high as fish primarily were observed in the lower three sites closest to stratum 6. These high densities emphasize the importance of the mined area to chinook salmon rearing during a good seeding year.

Densities of age 0+ chinook in August were much greater in 1989 than in the earlier years of the project. In 1989 the density of chinook went from a low of 0.2 fish/100m^{2}pool in stratum 1 to 117.8 fish/100m^{2}pool in stratum 7 (Appendix B). Prior to project implementation, densities ranged from 2-31 fish/100m^{2}pool in 1984 (Konopacky et al. 1986). In 1985, during the early phase of construction, densities of chinook were only 0-15 fish/100m^{2}pool in the seven strata. Looking only at the area of rehabilitation (stratum 6), where it would be expected to first see changes in the habitat, the density of chinook in 1989 was 77 fish/100m^{2}pool (Appendix 2) compared to 24 and 15 fish/100m^{2}pool in 1984 and 1985, respectively (Konopacky et al. 1986). However, one should be hesitant to ascribe our observed increase in densities to the project. Densities of young fish are highly dependent on the number of redds from the previous year and placement of those redds. The redd count in Bear Valley Creek in 1988 was much higher than it has been in recent years which could account for the greater densities seen in 1989 (see Salmon Redd Count).

In previous years (1987 and 1988), Richards et al. (1989) speculated that late season increases in salmon density in upstream strata were due to movement of fish from lower strata. This premise was founded on that fact that very little spawning had occurred in these upstream areas and that fish tended to be larger in upstream strata by late summer, despite fewer accumulated degree days (Richards et al. 1989). In 1988, however, 12 redds were counted in stratum 6. We feel that in addition to possible upstream movement of fish, increased late summer densities of chinook salmon may partially be explained by movement of fish from off-channel habitat (sloughs) occupied earlier in the summer. Further, spawning may occur later in the upper BVC strata. This year we documented 1 redd in stratum 7 two weeks after our initial redd survey. This being the case, it is possible that in previous years undetected spawning may have occurred in upper BVC. This may partially account for the past observations of increased fish densities later in the summer in upper BVC (attributed to upstream movement), if these fish primarily used off-channel habitat earlier in the summer.

Slough Assessment. We evaluated off-channel sloughs within strata 2-7 of Bear Valley Creek twice during the summer (early July and late August) to determine their importance to chinook salmon rearing. Physical characteristics of sampled units are presented in Table 7 for both sampling periods. Densities of chinook salmon in all sloughs combined (July 5-7) were significantly greater ($P < 0.001$) than densities observed in channel sites (June 26-30) in early summer (Figure 9). Again, it should be noted that our channel densities at this time were representative of pool habitat only; had other habitat components been included, the disparity between chinook salmon densities in slough and channel. habitat would have even been greater. This density difference between channel and slough sites was not observed in late August (Figure 9). During session 1, chinook salmon densities were greatest in strata 6 and 7 sloughs, 134 and 59 fish/100m^2, respectively (Figure 9). The highest slough density observed in lower BVC was stratum 2 (34 fish/100m^2).

Table 7. Mean and standard error for physical characteristics of sloughs sampled in strata 2-7 of Bear Valley Creek during session 1 (5-7 July) and session 2 (21-22 August), 1984.

Session	Area (m^2)	Ave. Depth (m)	Temp (C)	
			slough	river
1 (n=11)	84.1 (13.8)	0.26 (0.15)	13.0 (0.4)	11.1 (0.3)
2 (n=11)	70.3 (11.0)	0.18 (0.09)	18.9 (0.4)	18.3 (0.6)

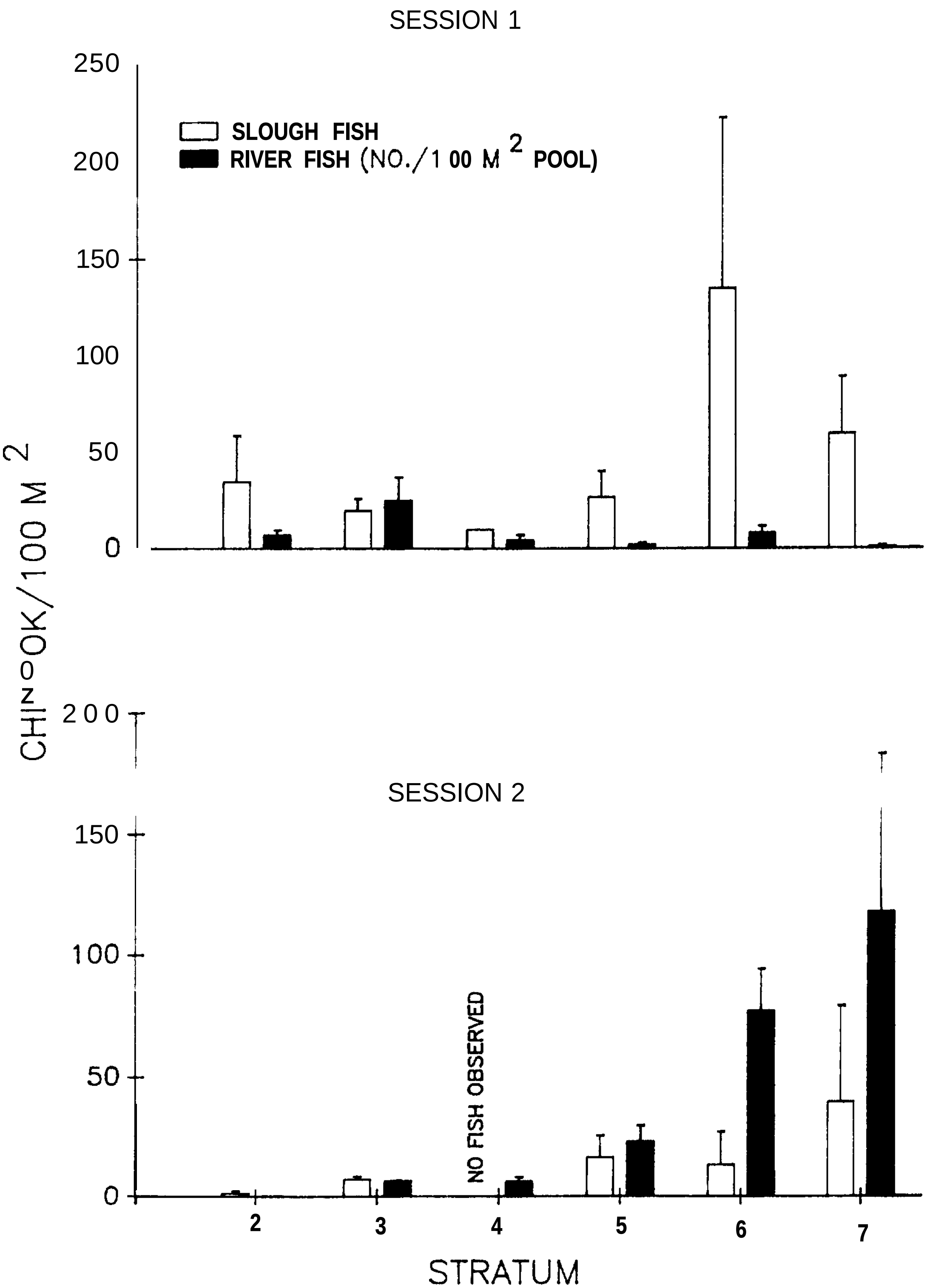

Figure 9. Comparison of chinook salmon densities in slough and stream sites during slough session 1 (5-7 July) and session 2 (21-22 August), Bear Valley Creek, 1989. Error bars represent the standard error about the mean,

Slough habitat likely offers early season refugia from higher flows to rearing salmon. During session 1, the greatest discrepancy between slough and river densities occurred in strata 6 and 7 where we observed very few chinook salmon in channel sites (Figure 9). By August, in strata 6 and 7, fish still used the sloughs, but densities were greater in stream sites (Figure 9). It appears that fish move into the sloughs early in the season to escape higher flows. As flows recede, fish movement out of sloughs back into the channel would explain our observed increase in salmon density for strata 6 and 7 by late August. In BVC, this was especially apparent in upstream strata where protection from high flows in the channel proper is probably less than in downstream habitats.

Warmer water temperatures in sloughs may afford fish in these habitats a growth advantage. During session 1, mean water temperature in the sloughs were 13.0°C, nearly two degrees warmer than adjacent stream sites (Table 7). Mean lengths of chinook salmon were significantly greater in sloughs than in channel sites in all strata except strata 2 and 4 during early July (Figure 10). Mean length of chinook salmon in sloughs ranged from 53.4 mm (stratum 7) to 61.6 mm (stratum 3). In channel sites mean fish lengths ranged from 47.2 mm (stratum 6) to 58.8 mm (stratum 2). By August fish lengths were not different between slough and channel fish (Figure 10), and water temperatures between habitat types were nearly equal (Table 7). Again, this supports the idea that slough habitat is a critical early season component to juvenile salmon rearing.

Age 0+ Steelhead Trout. Densities of age 0+ steelhead trout were much lower than chinook salmon in all strata throughout the summer (Appendix B). Age 0+ steelhead densities were greatest in August in strata 6 and 7 at 2 and 4 fish/100 m^2 pool, respectively (Figure 11). Very few steelhead were observed

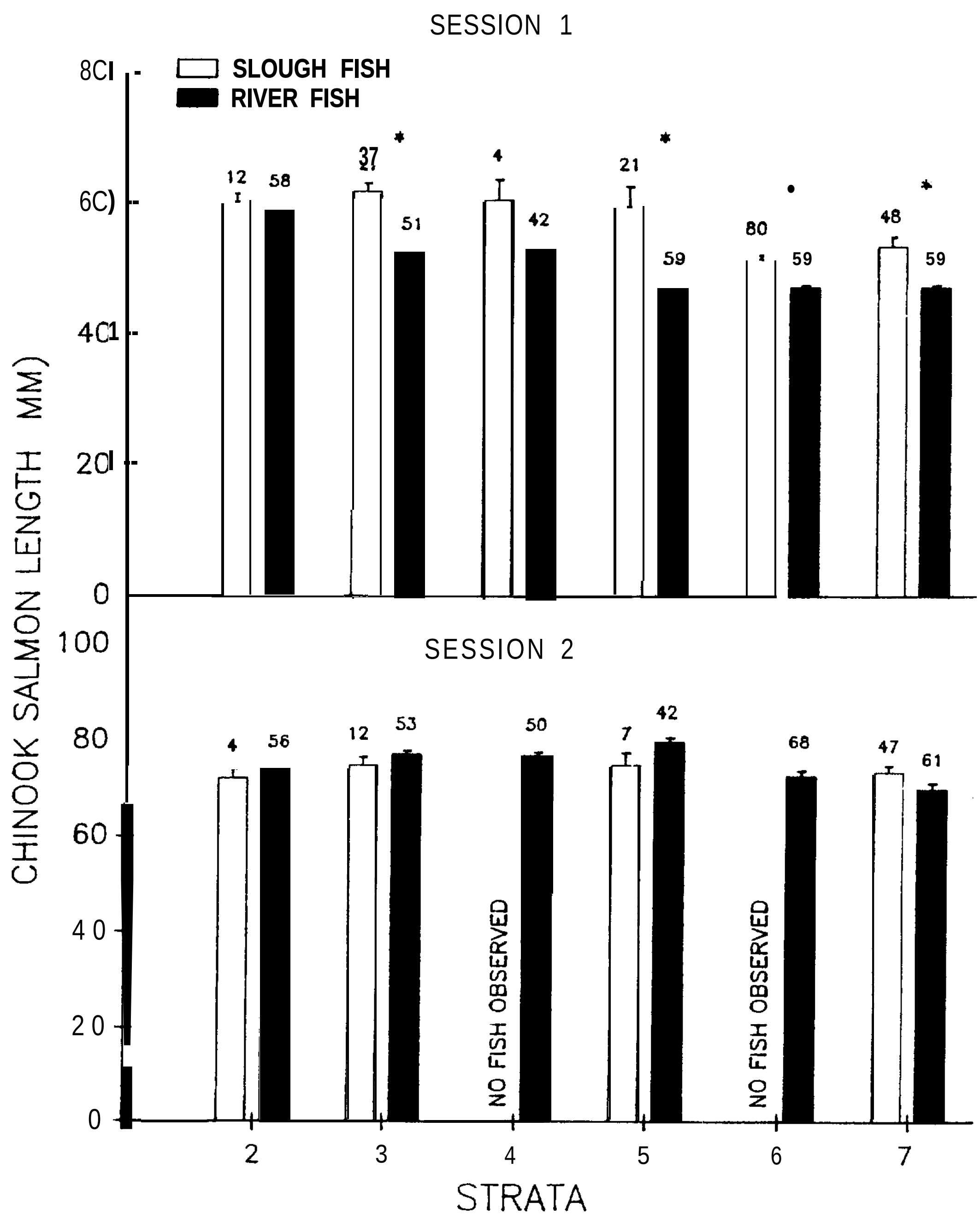

Figure 10. Mean and standard error of chinook salmon lengths sampled in slough and channel habitat during slough session 1 (5-7 July) and session 2 (21-22 August), Bear Valley Creek, 1989. Numbers above each bar represent sample size and an asterisk indicates a significant (P< 0.05) difference between means.

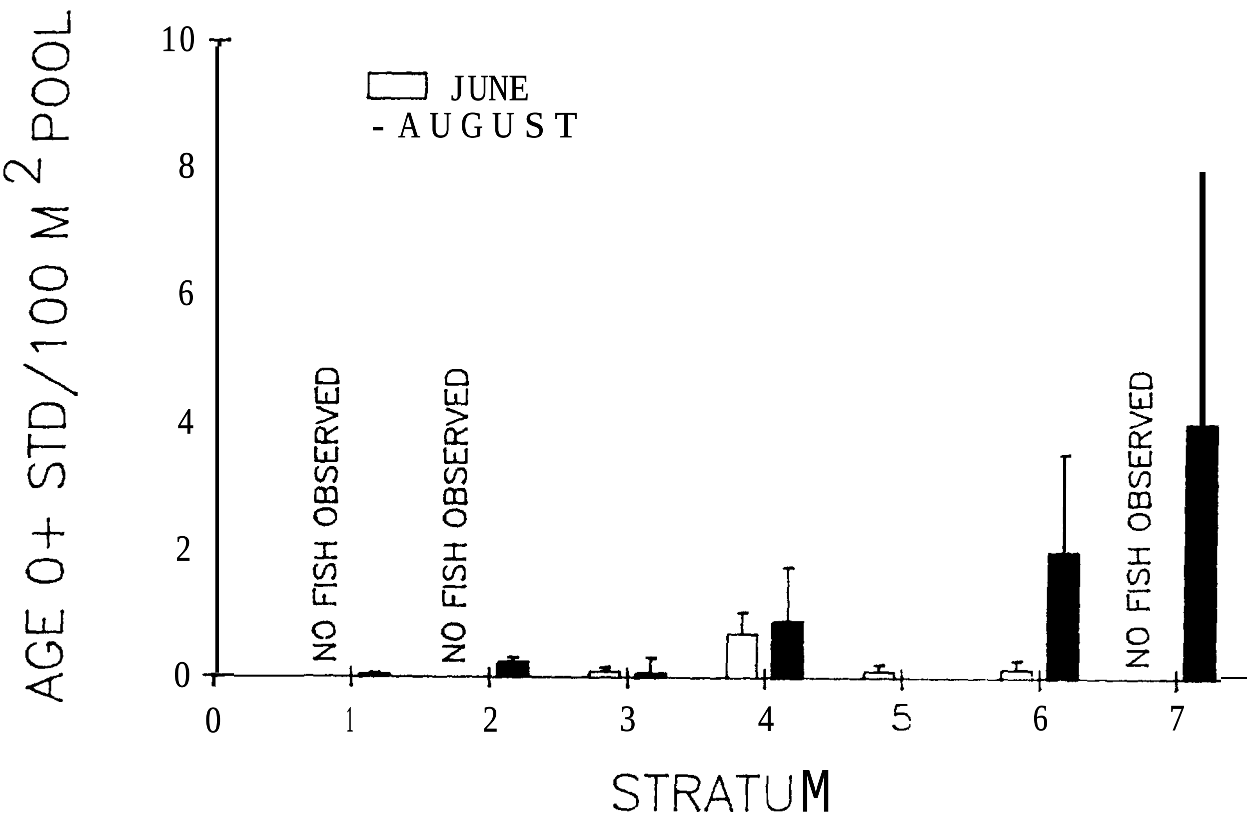

Figure 11. Density of age 0+ steelhead trout in strata l-7 (n=7 per stratum) between June and August, Bear Valley Creek, 1989. Error bars represent 95% confidence intervals of the mean.

in lower strata during the summer. Even though densities of young-of-the-year steelhead were varied between session and among strata, these differences were not significant.

Whitefish. The density of age 0+ whitefish was significantly different among strata and between sessions (Figure 12). As with young-of-the-year steelhead, age 0+ whitefish were observed in greatest densities in strata 6 and 7 during August (10 and 20 fish/100m^{2}pool, respectively). Similar to 1988 (Richards et al. 1989), June densities were extremely low with fish only observed in the lower four strata. During our June session, most whitefish had either not emerged or were so interspersed in cover that they were not observed at this time. August densities were significantly greater than those of June.

The density of adult whitefish differed only among strata (Table 6). Stratum 1 and 2 had significantly greater aensities than all other strata (Figure 13). In general, downstream strata had the highest densities during both sessions. In June, no whitefish adults were observed in strata 4-7 (Figure 13). This trend was also noted in 1988 (Richards et al. 1989). Upper sections of Bear Valley Creek appear to be the primary areas of young-of-the-year rearing with adults primarily using downstream sections where pools are larger and deeper.

Relative Abundance, Population Estimates, Egg to Parr Survival

Relative abundance of species changed from early to late summer, especially in lower Bear Valley Creek. During June 1989, the relative composition of all species (all age-classes combined) was dominated by age 0+ chinook salmon, ranging from 58% in stratum 2 to 96% in stratum 6 (Figure 14). Stratum 2 was the only section in June that had a considerable percentage of

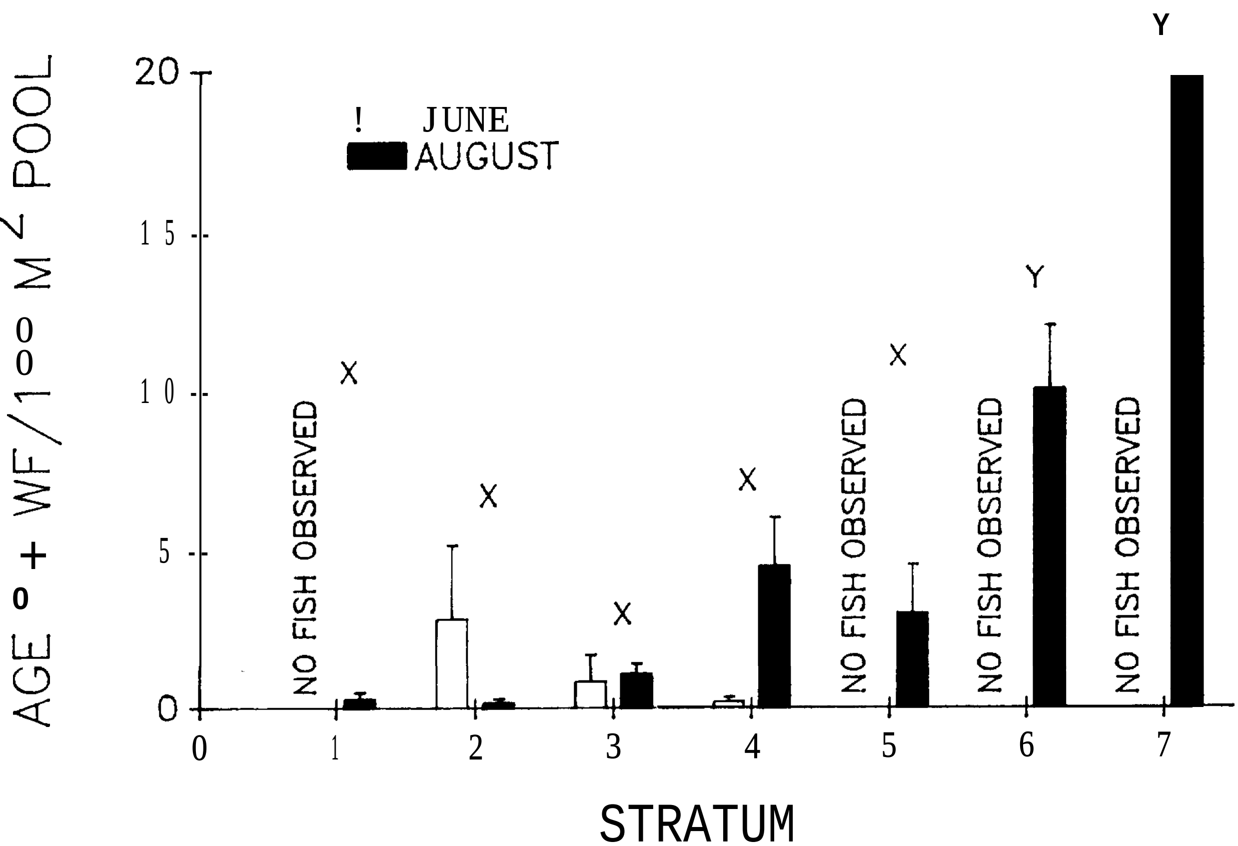

Figure 12. Density of age 0+ whitefish in strata l-7 (n-7 per stratum) between June and August, Bear Valley Creek, 1989. A common letter next to strata means indicates no significant ($P < 0.05$) difference among strata. Error bars represent 95% confidence intervals of the mean.

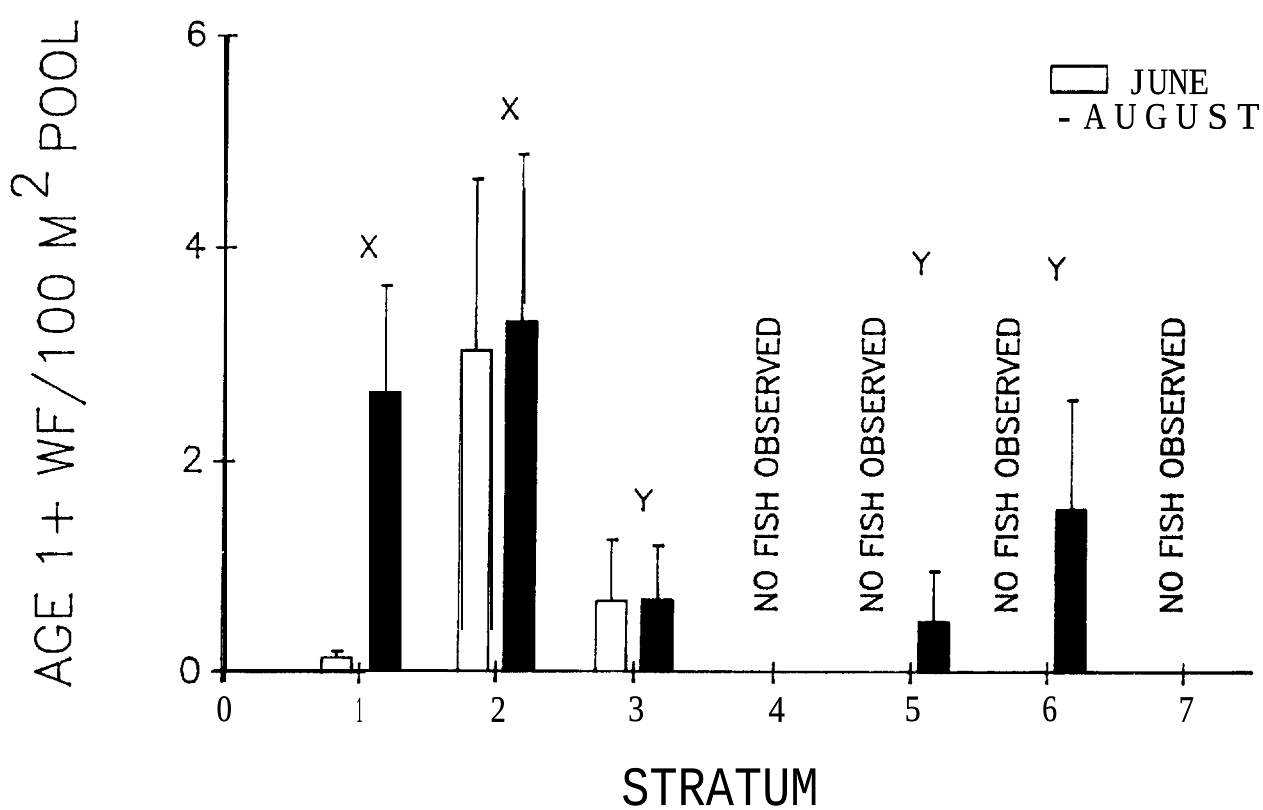

Figure 13. Density of age 1+ and older whitefish in strata 1-7 (n=7 per stratum) between June and August, Bear Valley Creek, 1989. A common letter next to strata means indicates no significant ($P < 0.05$) difference among strata. Error bars represent 95% confidence intervals of the mean.

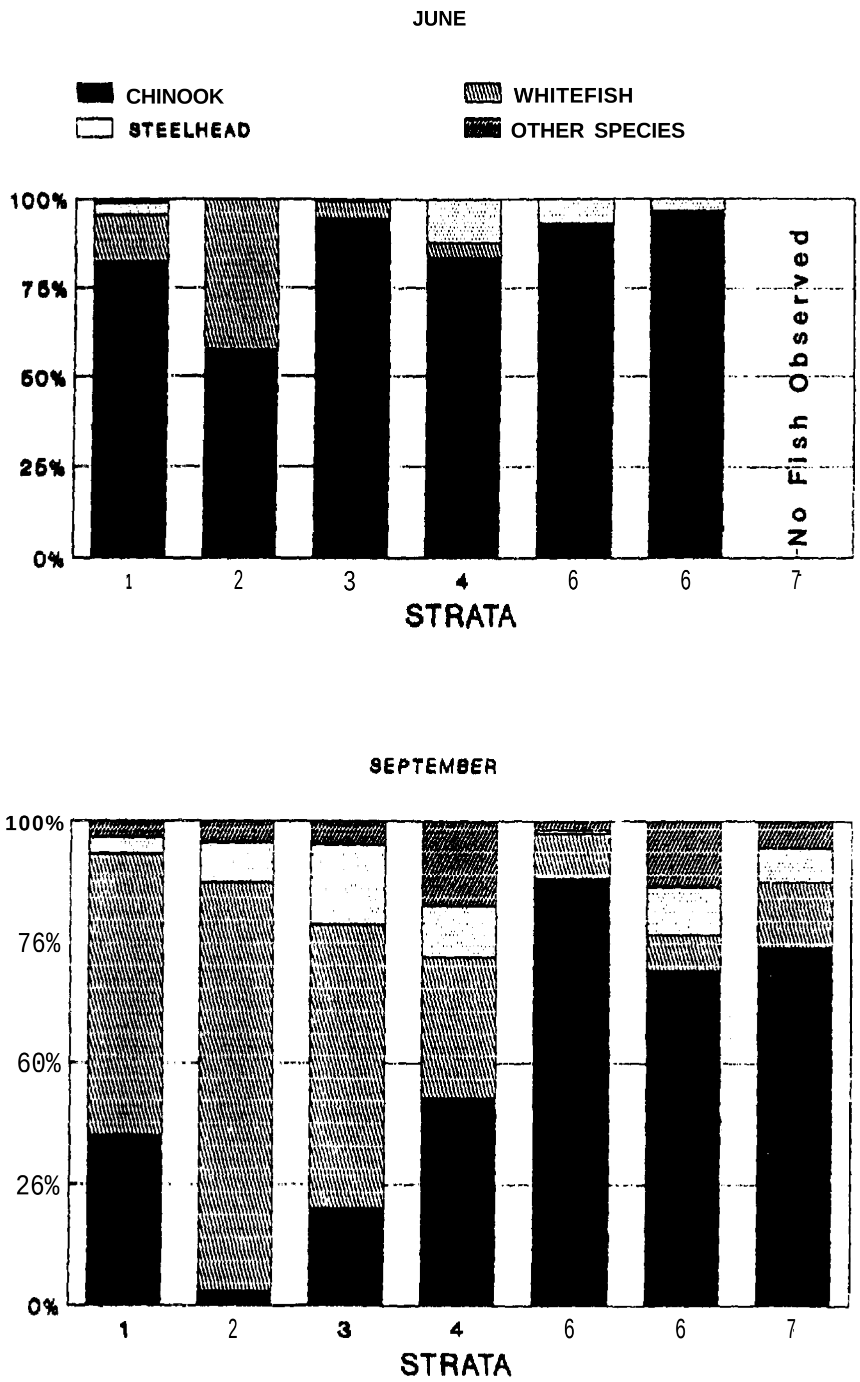

Figure 14. Relative abundance of fish species by strata in June and August, Bear Valley Creek, 1989. Other species = Brook trout, Bull trout and Cutthroat trout.

another species; whitefish constituted 43% of the fish community in this stratum. By late August the fish community composition had changed relative to June. Chinook salmon still dominated upstream strata 5-7, but strata l-3 were dominated by whitefish (Figure 14). Stratum 4 had the most equitable distribution of all species.

In June, we estimated the total number of age 0+ chinook salmon to be 21,000 fish. This is similar to the 1988 estimated abundance in July of 1988 (Richards et al. 1989). The greatest numbers of salmon were observed in downstream areas, strata 1-3, in June (Figure 15). This number should probably be considered only a minimum estimate as large numbers of chinook salmon are probably present in upstream strata but using slough habitat. We did not account for the number of fish using sloughs since we do not have a good estimate of the amount of slough habitat present.

By late August, we still observed large numbers of chinook salmon, but most fish were distributed in strata 5-7 by this time. We calculated a 10% reduction in salmon numbers to 19,000 fish from June to August. In 1988, a 70% reduction in salmon numbers from July to September was estimated (Richards et al. 1989). In 1989, since our last session was at the end of August, we may have caught many of these fish before they had moved out of the system in response to decreasing water temperatures,

In 1988, 234 redds were counted in Bear Valley Creek. We assumed 5,894 eggs were deposited in each redd (Howell et al. 1985) to estimate a minimum egg to June parr survival of 1.5%. This survival estimate is considerably less than the 4.4% estimated in 1988. Also, in 1984 and 1985, egg to parr survival was estimated at 5.6 and 4.8%, respectively, based on redd counts of 55 in 1983 and 17 in 1984. Thus, over the past five years, egg to parr survival was higher when the number of redds counted in Bear Valley Creek were

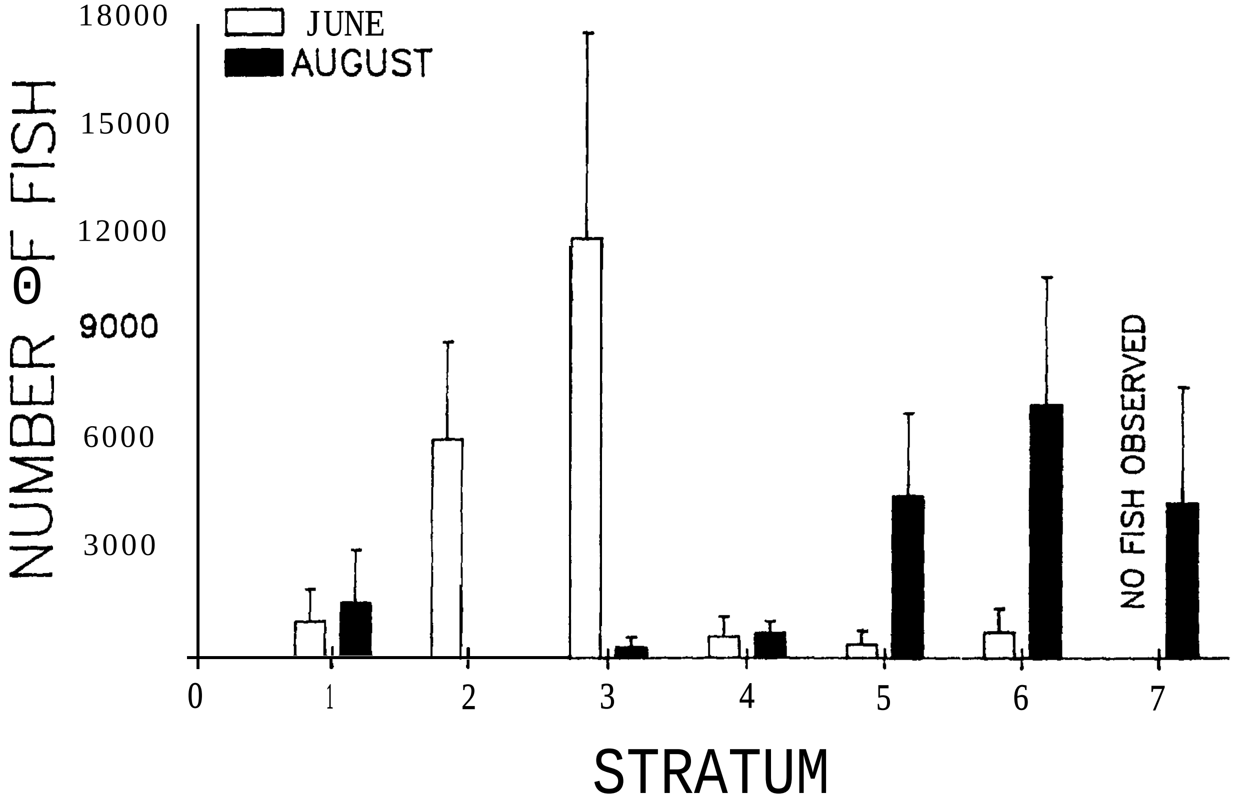

Figure 15. Total abundance of age 0+ chinook salmon in July and September by strata, Bear Valley Creek 1989. Error bars represent 95% confidence intervals of the mean.

less than 100. The cause for this apparent trend is unclear. In pre-mining years (early 1950's), redds in excess of 1000 were documented. Since this time, the rearing capacity of the system has obviously been reduced because of habitat degradation. However, we do not feel that the 1988 return, producing 234 redds, was at a level where density-dependent mortality becomes a factor. Other causes, such as differential use of slough habitat by juvenile salmon in relation to different flow regimes, and the distribution patterns of redds in the system from year to year have no doubt introduced confounding effects in our survival estimates.

Salmon Redd Count

On 23 August we counted 17 redds. This was far less than the 72 and 234 redds counted in 1987 and 1988, respectively. All redds but one, (stratum 7) were found in strata 2 and 3 (Table 8). This differs considerably from 1988 when 28X of the redds were counted in strata 4-6. The lack of upstream redds in 1989 is likely due to low number of spawners and the availability of suitable spawning gravels downstream. This is consistent with counts made in 1983, 1984, and 1987 when less than 100 redds were counted, most of which were observed in the lower portion of the drainage (Richards and Cernera 1588).

Fisheries Summary 198Y

Total mean fish densities throughout Bear Valley Creek tended to be low. This is consistent with previous years' data. However, chinook salmon densities were greater thoughout the summer in 1989 compared to 1988. Similar to previous years the greatest numbers of chinook salmon in early summer were located near the concentration of the previous year's redds. By late summer this distribution had shifted to the upper portions of Bear Valley Creek in the vicinity of the rehabilitated section of stream (stratum 6). During

Table 8. Distribution of redds found in Bear Valley Creek, 1989.

STRATUM	REDDS COUNTED	% OF TOTAL
1	NC	
2	7	41
3	9	53
4	0	0
5	0	0
6	0	0
7	1	6
TOTAL	17	100.0

NC = Not Counted

1986-88, the increase in salmon in the upper strata was assumed to be a result of fish moving up from lower strata. Richards and Cernera (1988) attributed this movement to increasing temperatures in downstram strata. While we feel that temperature may be the cause for chinook salmon abundance reductions in lower strata, we think late summer salmon increases in upper strata is primarily due to movement of fish out of sloughs. In July 1989, slough habitat was most heavily utilized in strata 6 and 7 with concurrent low densities in channel sites of these strata. By August few fish were left in slough habitat. This indicates that at least some of the increased numbers of chinook salmon in upper strata may be attributed to movement of fish out of sloughs. We should be able to get a better handle on this problem in 1990 since only one redd was counted in Stratum 7. If we do not document much fish use of upper strata slough or channel habitat in June, but observe fish in channel sites by late summer, then upstream movement may be the key factor to increased late summer salmon abundance in upper BVC. Because of what appears to be extensive early summer use of slough habitat, our estimates of chinook salmon abundance may be low. This would also cause our egg to parr survival estimates to be low since Bear Valley Creek has an extensive network of off-channel sloughs.

FUTURE MONITORING

In 1990 we will focus our physical habitat monitoring around the mined area, strata 5, 6, and 7. We intend to increase our core sampling effort to reduce variability that has been observed in the past. Further, we will initiate a more extensive survey of surface substrate embeddedness measures (Burns 1984). We will continue our survey of riparian and floodplain cover to track vegetation improvements over time. Habitat mapping and channel sinuosity measures will be undertaken in 1990. Fish sampling efforts will continue as in the past with the inclusion of a more extensive slough investigation, including quantification of the amount of slough habitat available. This should allow us to quantify the contribution of this habitat type to chinook salmon production in Bear Valley Creek. We will also include fish densities from riffle habitat throughout the summer. This will allow us to more appropriately compare our density data to that produced by other management entities.

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Appendix **A.**

Final Construction Summary

The 1989 field season marked the end of the planning, design and construction phase of the Bear Valley Creek Fish Enhancement Project. Initial planning and design began in 1984. Major construction activity on Bear Valley Creek started in 1985 and ended in 1988. Final revegetation efforts finished In 1989.

A total of 1.5 miles of Bear Valley Creek was stabilized. In some reaches, banks on both sides were modified, bringing the total length of stream bank stabilized to 2.5 miles. A brief summary of **activites** by year are as follows:

1984 - Site visit and assessment. Planning and design.

1985 - Planning and design. Permit acquisition. Floodplain development and riprapping along 1800 linear feet of stream. Development of a **riprap** source. Construction of berm along the stream. Revegetation.

1986 - Permit acquisition, Floodplain development along 2550 linear feet of stream. Stream stabilization of two tributaries, 530 linear feet and 65 linear feet, respectively. Fence built. Revegetation.

1987 - Permit acquisition. Floodplain development along 3012 linear feet of stream and stream stabilization along 155 linear feet of tributary stream. Excavated and backfilled three ponds. Developed second **riprap** source. Revegetation.

1988 - Permit acquisition. Floodplain development along 1900 linear feet of stream. Bank stabilzation on 410 linear feet of stream. Excavation and disposal within project site. Revegetation.

1989 - Revegetation.

Soil, muck, and rock were all moved at sometime during the construction phase. Earthwork included cut, fill, and disposal with almost 280,000 cubic yards handled. Three riprap sites were developed for the 16,400 cubic yards of rock hauled and installed at the edge of the floodplain.

Both onsite and offsite areas were revegetated. Eighty acres of the floodplain were seeded and fertilized. Almost 16,000 seedlings of willow, lodgepole, and spruce were planted onsite. Approximately 680 Carex plants were transplanted along the stream. Offsite reclamation of the three riprap sites involved 16 acres.

A log worm fence was constructed around the site. The 20,000 linear feet of fence encloses the 245 acres of the construction site.

Water quality monitoring was conducted throughout the life of the project. Of most concern was sediment, turbidity, metals, and nutrient input to Bear Valley Creek during construction. At no time did water quality fail to meet state standards.

A visual history was implemented to document progress of the project. Permanent photo points have been established in each construction reach. These photo points allow not only comparison of Bear Valley Creek from a pre- versus post-construction perspective, but also to follow the dynamics of the modified stream and floodplain, Several years of aerial photos will also assist in this documentation.

In the original feasibility study (March 1985) total cost of the project was estimated at $3.8 million. As of 31 January 1990, total expenditures were at $2.8 million.

No further construction activity in Bear Valley Creek is foreseen. Although the project was designed for a low to no level of operation and maintenance, minor 0 & M (e.g., some revegetation work) may occur. In addition monitoring and evaluation will continue to verify the effects of the project.

Appendix B.

Mean total fish densities (fish/100m^2 pool) by session and strata.

STRATUM	CHS YOY	STH YOY	STH A&B	WHF YOY	WHF JUV	WHF AD	BKT ALL	OTH SPP	TOTALS
	Density by Species								
				Session 1 (June)					
1	0.8	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1
2	6.9	0.0	0.0	2.8	0.0	3.0	0.0	0.0	1.6
3	24.8	0.0	1.0	0.8	0.0	0.6	0.0	0.0	3.4
4	4.2	0.7	0.0	0.2	0.0	0.0	0.0	0.0	0.6
5	1.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3
6	7.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
7	0.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
				Session 2 (August)					
1	0.2	0.1	0.1	0.3	0.1	2.6	0.0	0.1	0.7
2	1.0	0.3	0.0	0.2	0.0	3.3	0.0	0.1	0.6
3	0.7	0.7	0.1	1.0	0.2	0.7	0.2	0.0	0.5
4	6.4	0.9	1.2	4.5	0.0	0.0	1.4	0.0	2.0
5	23.3	0.0	0.1	3.0	0.0	0.5	0.7	0.0	1.8
6	76.9	2.0	13.6	10.0	0.1	1.5	8.4	0.0	14.1
7	117.8	4.1	8.8	19.7	0.0	0.0	5.7	4.1	20.0

ABSTRACT

Yankee Pork of the Salmon River

Extensive dredge mining degraded spawning and rearing habitat for chinook salmon (Oncorhynchus tshawytscna) and steelhead trout (O. mykiss) in the Yankee Fork drainage. of the Salmon River. Rearing habitat has been increased through the incorporation of old off-channel dredge ponds. Implementation of this work began in fall 1987 and was completed during the fall of 1988, with some revegetation work finalized in the spring of 1989. In 1989, we assessed fish communities throughout the Yankee Fork drainage to continue this data base, which provides a context for our pond work. Mean total fish densities on the Yankee Pork mainstem generally decreased from downstream to upstream reaches in both June and August. Since chinook salmon were the primary fish community constituent, the greatest total mean fish densities were generally associated around and downstream of chinook salmon spawning areas documented in 1988. Mainstem chinook salmon densities ranged from 0.6 to 4.3 fish/100m^2 pool. The West Fork of the Yankee Fork, a primary spawning tributary, had significantly ($P < 0.05$) greater densities than all other strata at 33 and 18 fish/100m^2 pool in June and September, respectively. In 1989, all chinook salmon spawning occurred in upstream sections of the Yankee Fork, 16 redds; and the West Fork, 6 redds.

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INTRODUCTION

The Yankee Fork of the Salmon River, a major tributary of the Salmon River, is a spawning and rearing stream for anadromous salmonids. Chinook salmon (Oncorhynchus tshawytscha) redd counts, that in the past (1960's through early 1970's) have exceeded 400 per year, are currently depressed to less than 50 redds per year in the 1980's. Although no redd count data exists, wild steelhead trout (O. mykiss) also utilize the Yankee Fork for spawning and rearing. In recent years, outplanting of hatchery steelhead trout and chinook salmon has occurred to supplement current natural runs. A considerable put-and-take rainbow trout fishery also exists in dredge ponds adjacent to Yankee Fork proper.

The Yankee Fork of the Salmon River system has a long history of adverse land use practices that have contributed to the decline of anadromous fish runs. Several miles of stream habitat in the lower Yankee Fork and lower Jordan Creek have been severely altered by dredge-mining for gold since the late 1800's. Much of the natural meander pattern of the stream and associated instream habitat and riparian vegetation has been lost. Extensive unconsolidated and unvegetatea dredge tailings have increased sedimentation of spawning riffles and rearing pools and reduced riparian cover.

Smolt production potential in the Yankee Fork is quite high. The Salmon River subbasin plan (Kiefer et al. 1989) estimated that at full seeding the Yankee Fork drainage could produce 425,000 spring chinook smolts and 59,000 steelhead smolts. BNI (1987) estimated a potential in Yankee Fork of producing 740,000 chinook snolts and 295,000 steelhead smolts.

With funding from Bonneville Power Administration (BPA), the Tribes initiated pre-treatment biological and habitat inventories (Konopacky et al.

1986, Richards and Cernera 1987), identified habitat problems and conducted a detailed analysis of feasible alternatives for anadromous fisheries enhancement in the Yankee Fork drainage (BNI 1987). Rearing habitat in the Yankee Fork was determined to be limiting to anadromous fish production. Enhancement efforts were targeted at increasing available rearing habitat. Four series of off-channel ponds were connected to the Yankee Fork through excavation of channels and the construction of check structures to control flow in and out of the ponds. Work on these off-channel rearing areas was completed in fall 1988 (Richards et al. 1989).

The objectives of this study were to continue assessment of fish communities in the Yankee Fork drainage. Part II of the Yankee Fork subproject documents habitat use, growth, and abundance of outplanted and naturally produced chinook salmon juveniles within the system on ponds.

STUDY AREA

The Yankee Fork of the Salmon River, located on the Challis National Forest in Custer County, Idaho, is a major tributary of the upper Salmon River. The Yankee Fork is a medium-gradient system which flows through narrow canyons and moderately wide valleys of lodgepole pine (Pinus contorta) forests. Investigations were conducted on; the mainstem Yankee Fork from its confluence with the Salmon River upstream to Mckay Creek (including four off-channel pond series located in the lower reaches of Yankee Fork), on the West Fork of Yankee Fork from its confluence with Yankee Fork upstream to Cabin Creek, and Jordan Creek from its confluence with Yankee Fork upstream approximately 7km (Figure 1). In addition to chinook salmon, other fish species present in the Yankee Fork include: bull trout (Salvelinus

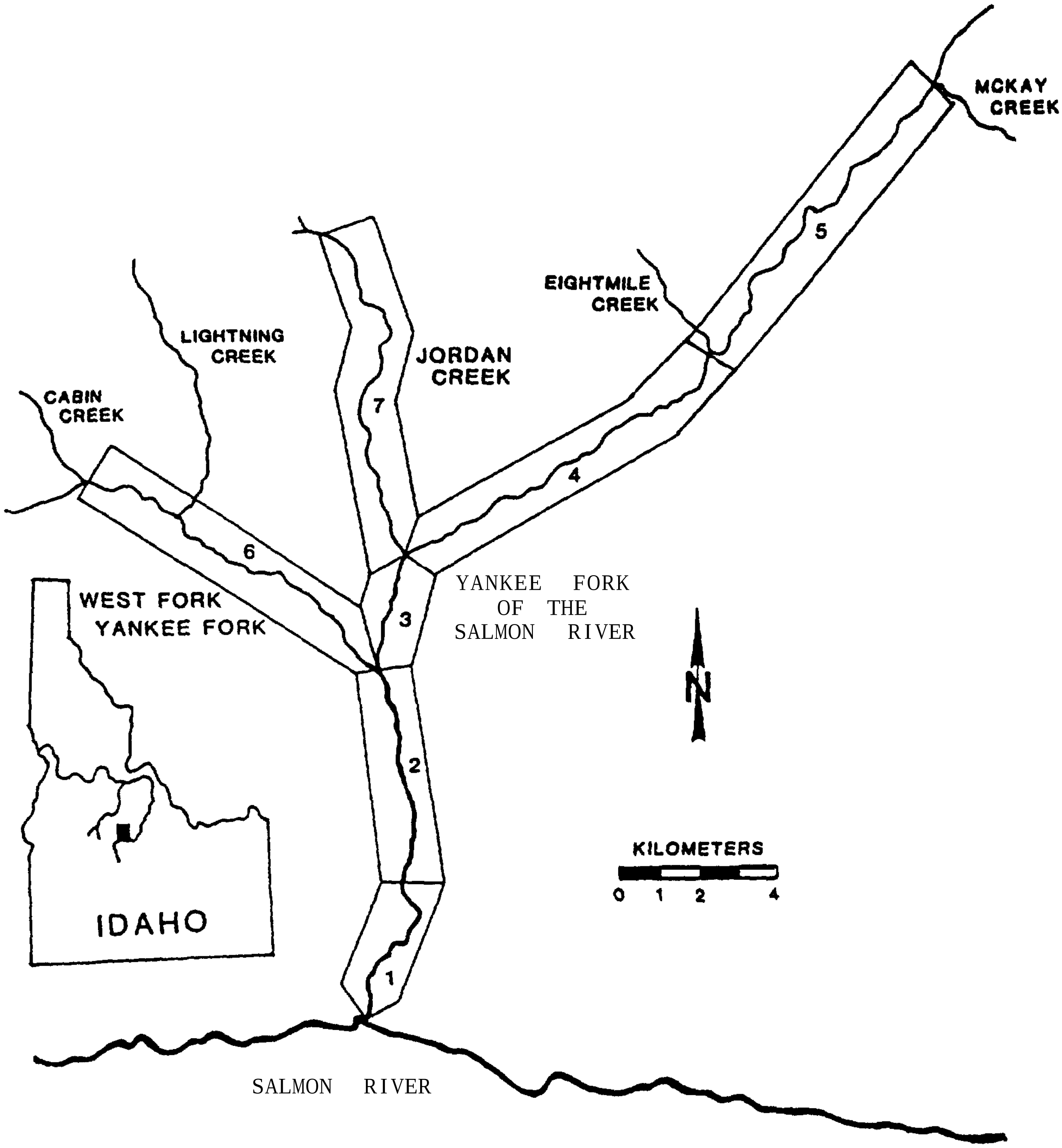

Figure 1. **Yankee** Fork drainage of the Salmon River, Idaho, study area and strata location.

confluentus); cutthroat trout (O. clarki); mountain whitefish (Prosopium williamsoni); shorthead sculpin (Cottus confusus); and sucker (Catostomus spp.).

METHODS

The Yankee Fork system was stratifed into seven strata by reach characteristics (Konopacky et al. 1586). Stratification was based on stream size, valley width, gradient , overland vegetative community type, and land use associated with the stream. Within a stratum (plot), seven systematically determined sites (replicates) were used in our 1989 sampling design. These sites have been in place and sampled since 1985. In 1989, we sampled each site within a stratum for fish density by species. Prom this, we were able to determine species composition and relative abundance, and the total abundance of chinook salmon.

We conducted fish counts during the second week of June and September. Observations were conducted by two divers equipped with snorkel and mask following the techniques outlined in Platts et al. (1983). All observations were made between 1100-1600 hours (MST). Wue to high flows, no fish counts were conducted in stratum 1 sites during June. Density (number of fish/m^2pool) of each species/age class was calculated as the number of fish in each size class divided by pool area. Densities within each strata were averaged to obtain a mean density of each species/age-class. We used two-way analysis of variance (2-way ANOVA) to compare fish aensities among strata and between sessions. When a main effect was significant, Tukey's multiple range test was applied to discern where the difference occurred. Individual density values were transformed (log base 10) to normalize data prior to using parametric statistics.

Relative abundance (%) was calculated as the number of fish in each species size class divided by the total number of fish present and multipled by 100. Total abundance of age 0+ chinook salmon was calculated for June and September from mean and variance values derived from snorkeling surveys using techniques given in Mendenhall et al. (1971).

During each snorkel session we collected and measured 50 (when possible) juvenile chinook salmon for total lengtn. Fish were collected by electrofishing (DC) various habitat types within a stratum. Prior to measurement, fish were anesthesixed with MS-222 (tricainemethanesulfonate). After we measured the fish, we allowed them to recover in a holding bucket of fresn, cold water before being released back into the stream.

We counted chinook salmon redds on 24 August along all mainstem Yankee Fork strata. We walked the West Fork for redds on 8 September. Counts were made by biologists wearing polarized glasses.

Both temperatures and flows were monitored, We used one Taylor maximum/minimum thermometer per stratum to monitor stream temperature throughout the summer. Total degree-days (average temperature in degrees Centigrade/day) were estimated for each stratum using a weekly “max-min” reading. Weekly “max-min” values were averaged and multiplied by 7 to generate degree-days per week. Weekly degree-day values were totaled for each stratum to obtain cumulative degree-days by stratum for the entire field season (6/13-9/13). We measured late season (September) low flows at one mid-stratum cross section for each strata,

RESULTS AND DISCUSSION

Densities

Mean total fish densities in the Yankee Fork system were greatest in West Fork (stratum 6) in June and September at 6.8 and 4.0 fish/100m^{2}pool, respectively (Table 1). During session 1, other than stratum 6, mean total fish densities were low, range 0.2-0.8 fish/100m^{2}pool. In the mainstem strata, densities generally decreased from downstream to upstream during both sessions (Figure 2). Mean total densities increased in all mainstem strata by September, range 0.3-2.1 fish/100m^{2}pool. This June to September increase may have been partially due to high flow conditions during our June session. At this time, fish keying in on substrate cover were difficult to enumerate and may have caused us to underestimate fish numbers. Similar to 1988, stratum 5 had the lowest total fish densities during both sessions (Richards et al. 1989).

Age 0+ Chinook Salmon Densities. Chinook salmon densities were generally similar between sessions within each stratum (Figure 3); however, we did detect a significant difference ($P < 0.05$) in salmon densities among strata (Table 2). West Fork densities were significantly greater than main river strata densities In June and September at 32.7 and 18.2 fish/100m^{2}pool, respectively (Figure 3). Chinook salmon densities from Yankee Fork mainstem strata ranged from 0.6-3.4 fish/100m^{2}pool in June and 1.0-4.3 fish/100m^{2}pool in September. Densities tended to be greater in iower strata and decreased in upstream strata (Figure 3). Strata with the greatest chinook salmon densities were either in or below areas of greatest spawning documented in fall 1988

Table 1. Mean total fish densities ($fish/100m^2$ pool) by session and stratum, Yankee Fork drainage of the Salmon River, Idaho, 1989.

	Density by Species					
STRATUM	CHS YOY	STH YOY	STH A&B	WHF YOY	WHF AD	TOTALS
			Session 1 (June)			
1	NS	NS	NS	NS	NS	NS
2	2.0	0.0	0.1	0.0	0.8	0.6
3	3.4	0.0	u.2	0.2	0.3	0.8
4	0.6	0.0	0.2	0.0	0.1	0.2
5	0.9	0.0	0.0	0.0	0.0	0.2
6	32.7	0.0	1.0	0.0	0.3	6.8
7	0.0	0.0	0.2	0.0	0.2	0.8
			Session 2 (September)			
1	4.2	1.0	1.7	0.2	3.2	2.1
2	1.6	U.3	0.0	0.1	3.1	1.2
3	4.3	0.1	(i.3	0.5	2.5	1.5
4	1.9	0.0	0.2	0.0	0.3	0.5
5	1.0	0.0	0.5	0.0	0.0	0.3
6	18.2	0.7	0.7	0.0	0.3	4.0
7	0.0	2.4	0.6	0.0	0.0	0.6

NS = Not Sampled.

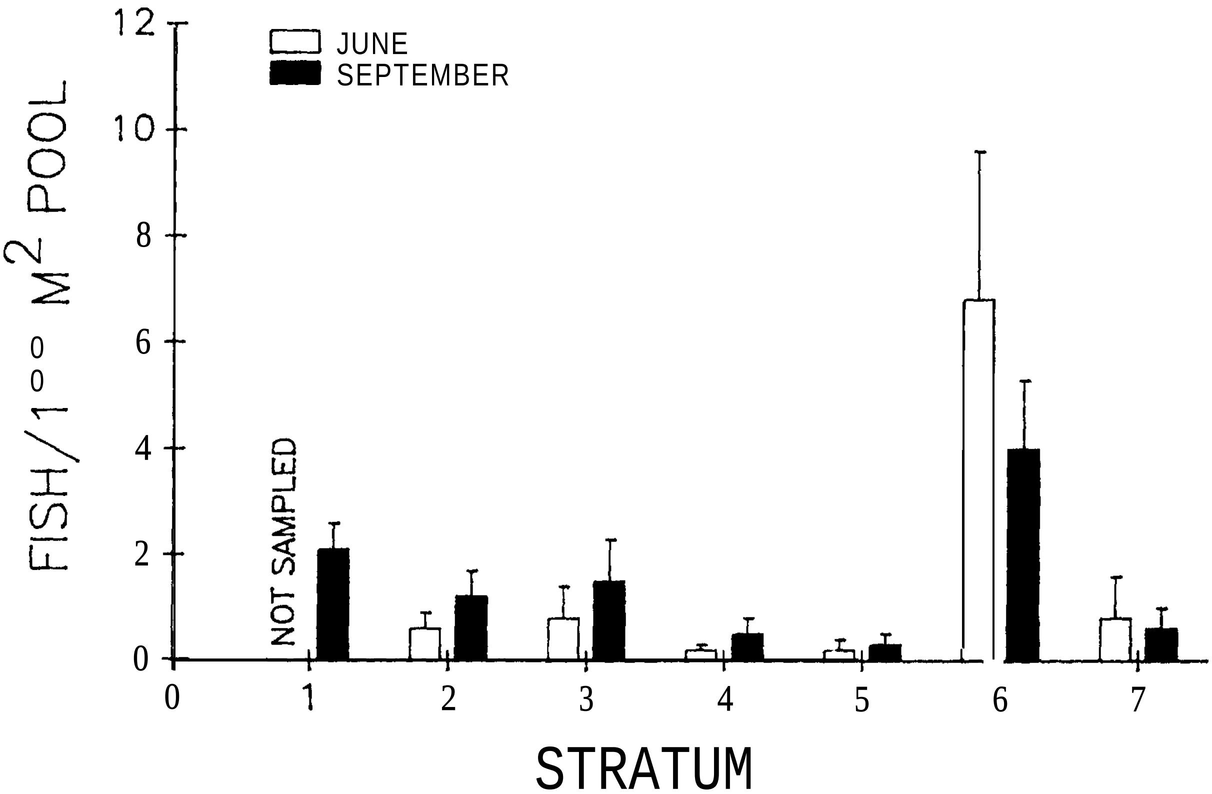

Figure 2. Total fish density by stratum (n=6 per stratum) for June and September, Yankee Fork of the Salmon River, 1989.

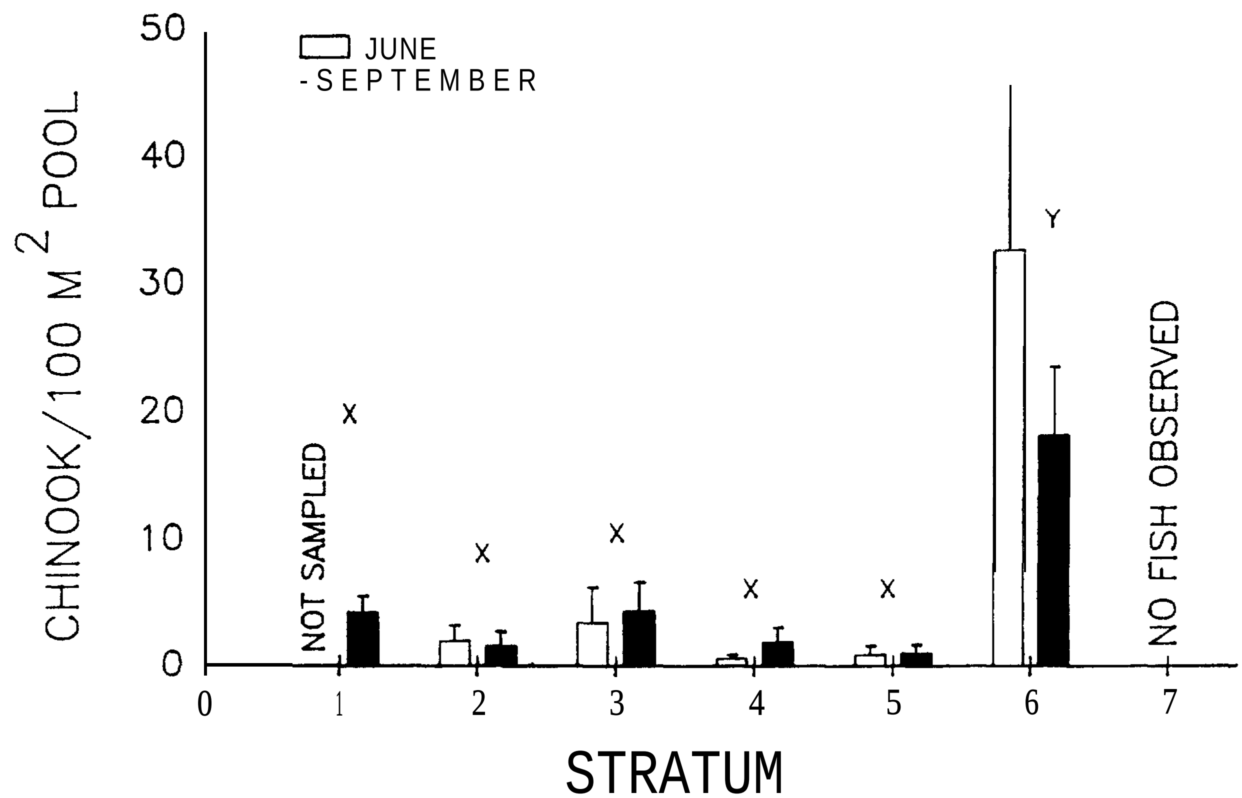

Figure 3. Density of age 0+ chinook salmon among strata (n=6 per stratum) and session, Yankee Fork of the Salmon river, 1989. A common letter indicates no significant ($P < 0.05$) difference among means with that letter. Error bars represent 95% confidence interval of mean.

Table 2. Two-way analysis of variance for fish species by age class, Yankee Fork of the Salmon River, 1989. The two non-metric independent variables were session and strata. Fish density was the independent metric variable. An asterisk next to a probability indicates significance for that factor.

SPECIES BY AGE CLASS	SOURCE:	DF	F VALUE	PROB.
	Stratum	6	11.9	0.00 *
Age 0+ Chinook	Session	1	0.1	0.74
	Session * Stratum	6	1.0	0.44
	Stratum	6	2.1	0.07
Age 0+ Steelhead	Session	1	8.0	0.01 *
	Session * Stratum	6	2.0	0.07
	Stratum	6	2.2	0.06
Age 1+ and older Steelhead	Session	1	3.9	0.06
	Session * Stratum	6	2.3	0.05
	Stratum	6	2.8	0.01 *
Age 0+ Whitefish	Session	1	2.3	0.13
	Session * Stratum	6	0.6	0.76
	Stratum	6	6.8	0.00 *
Adult Whitefish	Session	1	22.6	0.00 *
	Session * Stratum	6	5.2	0.00 *

(natural production) or near areas supplemented by hatchery fish (i.e., off-channel ponds) in 1989.

Age 0+ Steelhead Trout. We observed no age 0+ steelhead in any strata of the Yankee Fork until September. At the time of June sampling, the majority of steelhead emergence probably had not occurred. In September, we noted the greatest age 0+ steelhead density in Jordan Creek (stratum 7), 2.4 fish/100m^{2}pool (Figure 4). Densities ranged from 0.1-1.0 fish/100m^{2}pool in lower Yankee Fork strata and no steelhead were observed in strata 4 and 5.

Age 1+ and Olaer Steelhead Trout. We found no significant difference between sessions and among strata for age 1+ and older steelhead trout (Table 2). Densities were generally greatest during the September session for all strata, except 2 and 6 (Figure 5). In September, we noted the greatest 1+ and older steelhead densities in stratum 1 (1.7 fish/100m^2 pool) and the two tributary strata, 6 (3.7 fish/100m^{2}pool) and 7 (0.6 fish/100m^{2}pool).

Age 0+ Whitefish. Very few age 0+ whitefish were observed in our June snorkel session (Figure 6). In both sessions no age 0+ whitefish were observed in strata 4, 5, 6 (West Fork), and 7 (Jordan Creek). Stratum 3 had a significantly greater mean density (0.5 fish/100m^{2}pool) than strata 1 and 2 (G.2 and 0.1 fish/100m^{2}pool, respectively).

Adult Whitefish. Adult whitefish were significantly greater in our September sampling session (Table 2), and showed a decline in density from downstream to upstream strata (Figure 7j. Similar to 1988, adult densities were least in those strata with shallow pools and overall small stream size (i.e. strata 4 to 7). These data concur with other literature that documents whitefish

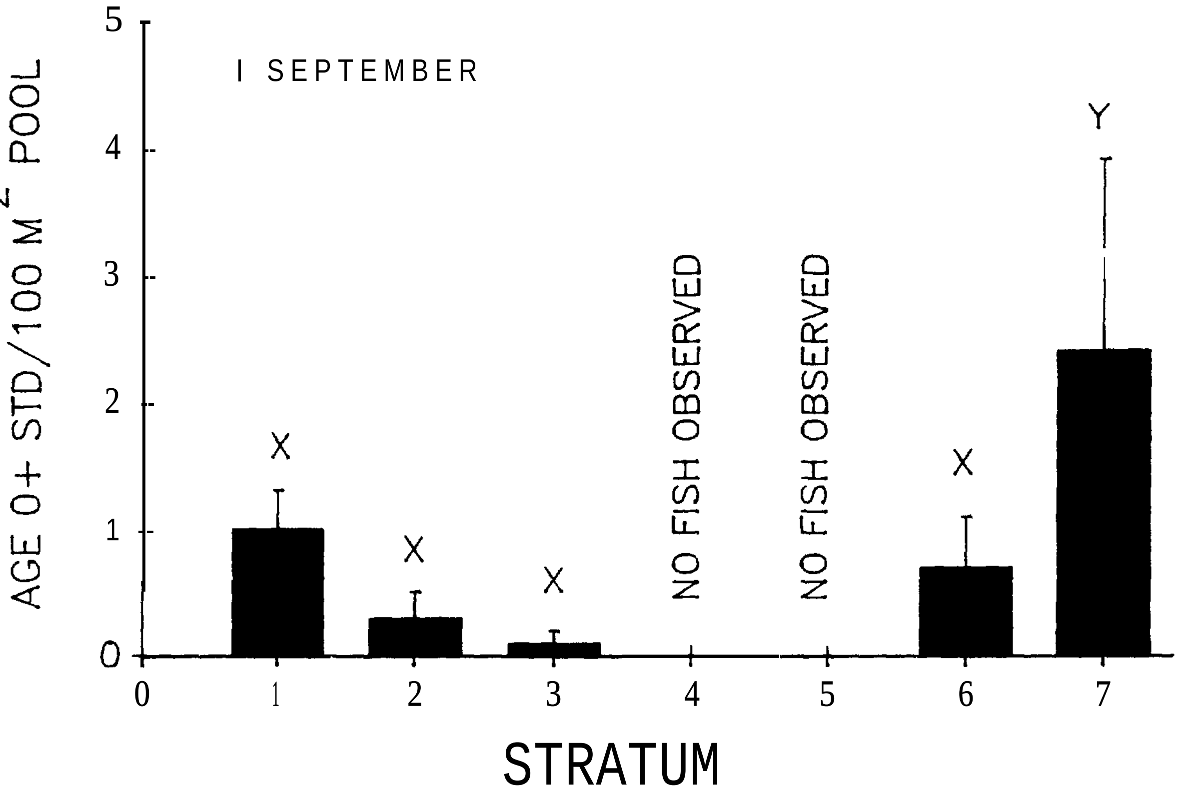

Figure 4. Density of age 0+ steelhead trout among strata (n=6 per stratum) and session, Yankee Fork of the Salmon River, 1989. A common letter indicates no significant (P< 0.05) difference among means with that letter. Error bars represent 95% confidence interval of mean.

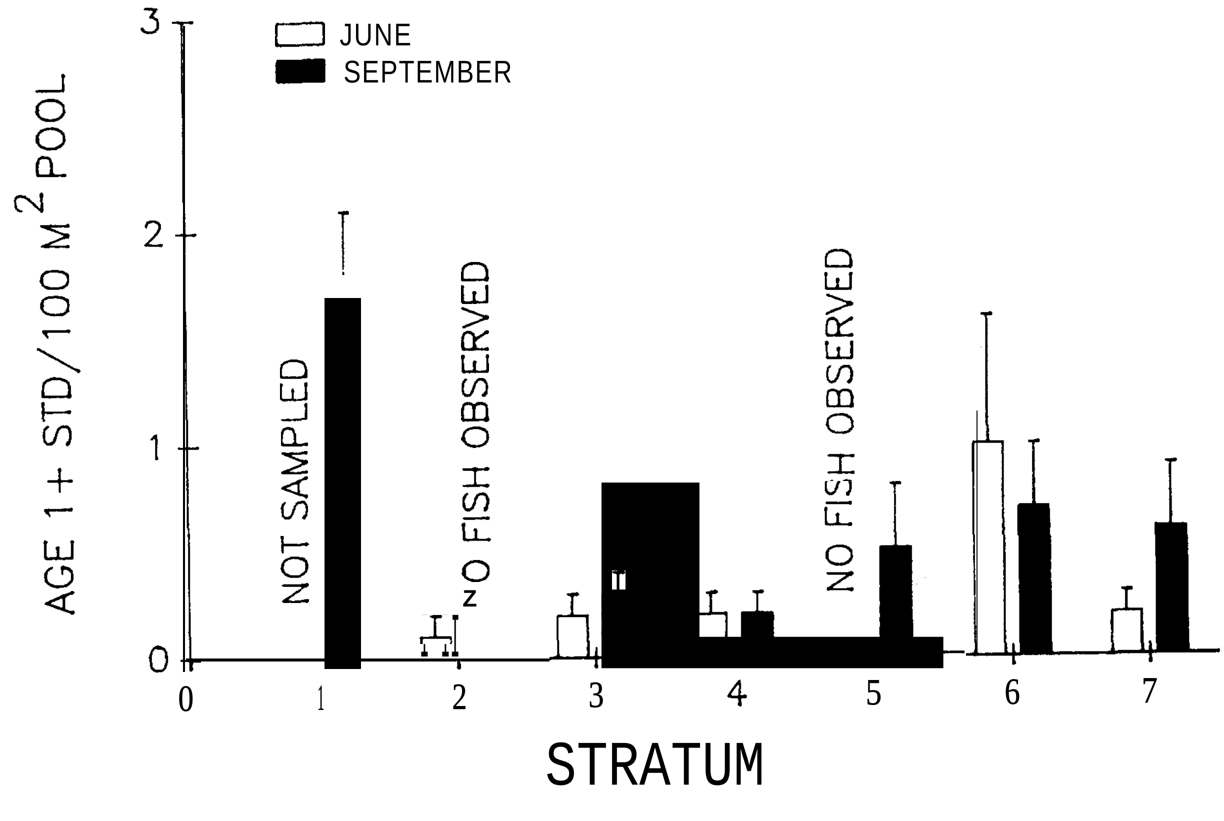

Figure 5. Density of age 1+ and older steelhead among strata (n=6 per stratum) and session, Yankee Fork of the Salmon River, 1989. Error bars represent 95% confidence interval of mean.

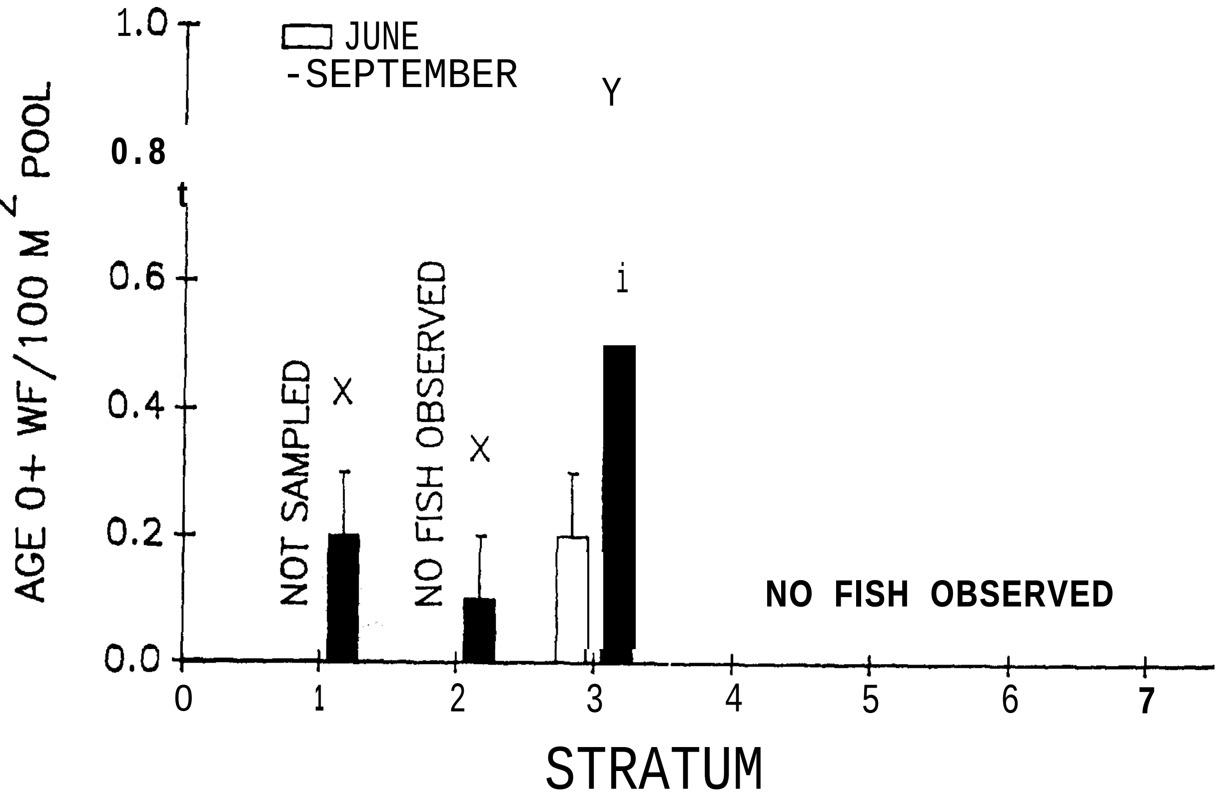

Figure 6. Density of age 0+ whitefish among strata (n=6 per stratum) and session, Yankee Fork of the Salmon River, 1989. A common letter indicates no significant ($P < 0.05$) difference among means with that letter. Error bars represent 95% confidence interval of mean.

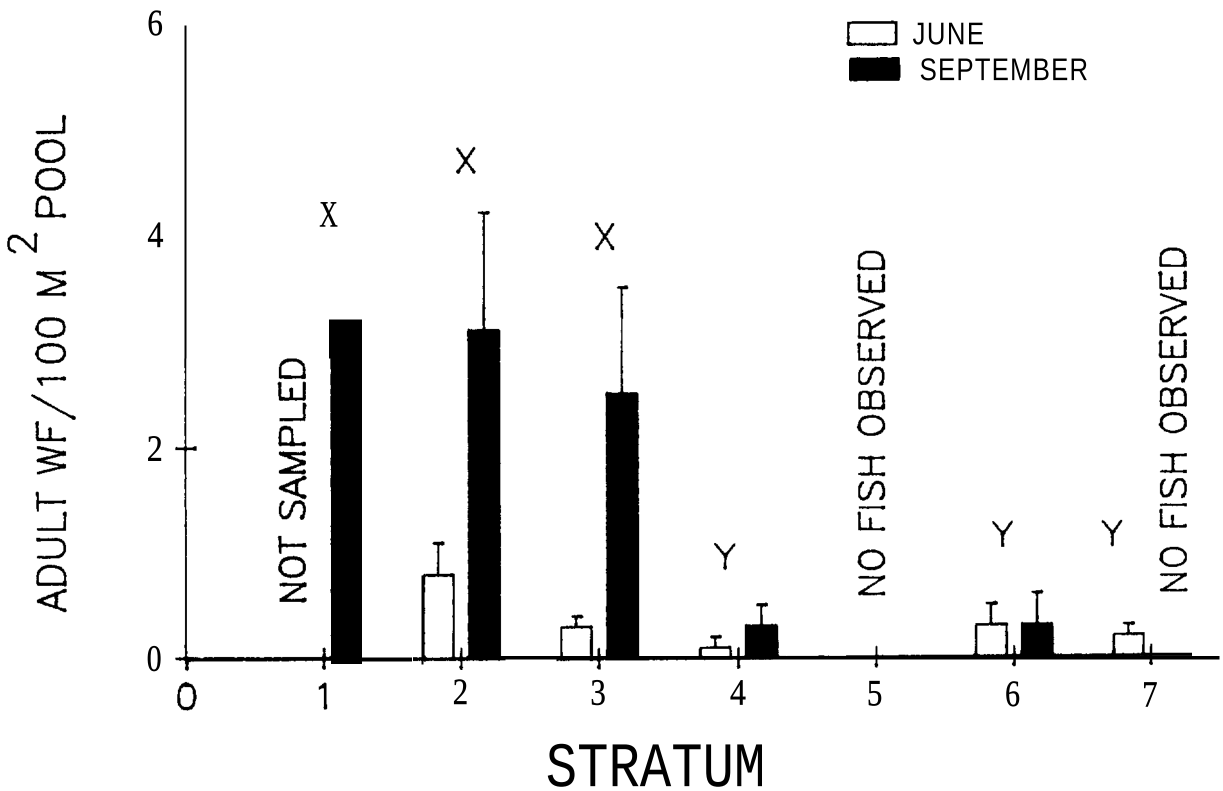

Figure 7. Density of adult whitefish among strata (n-6 per stratum) and session, Yankee Fork of the Salmon River, 1989. A common letter indicates no significant ($P<$ 0.05) difference among means with that letter. Error bars represent 95% confidence interval of mean.

habitat preference (Simpson and Wallace 1982). In strata 1 to 3, adult densities ranged from 2.5 to 3.2 fish/100m^2 pool.

Relative Abundance

In June chinook salmon constituted the largest proportion of the fish community in all strata, except Jordan Creek, stratum 7 (Figure 8a); cutthroat trout dominated stratum 7. Since late summer flow (0.05 m^3/s) in 1988 was extremely low in Jordan Creek, passage by adult salmon to suitable upstream habitat was probably not possible. This may account for the complete absence of this species in Jordan Creek during the last two years.

In September, chinook salmon represented a less substantial part of the fish community than in June. Strata 3, 4, and 6 (West Fork) fish communities were still dominated by chinook salmon (Figure 8b). In strata l-3, whitefish numbers became more important at this time. Also, in September, bull trout dominated stratum 5 and steelhead dominated Jordan Creek (stratum 7).

Length of Age 0+ Chinook Salmon

In June, there was a significant difference ($P < 0.01$) in length of fish among strata. Fish were largest in stratum 2 averaging 48.3 mm (SD=11.3 mm); smaller fish were found in upstream strata (Table 3). Strata 5 salmon were smallest with a mean and standard deviation of 39.6 mm and 1.8 mm, respectively. Movement of larger hatchery outplanted fish (24 May) from stratum 2 ponds into stratum 2 mainstem sites may have contributed to the larger fish in stratum 2, as outplanted fish averaged 62.1 mm at stocking. In 1988 fish were largest in stratum 4 in June. This was due to an egg-planting effort in this stratum during the fall of 1987. In the fall of 1988 no such effort was conducted. June fish lengths in all strata combined ranged from

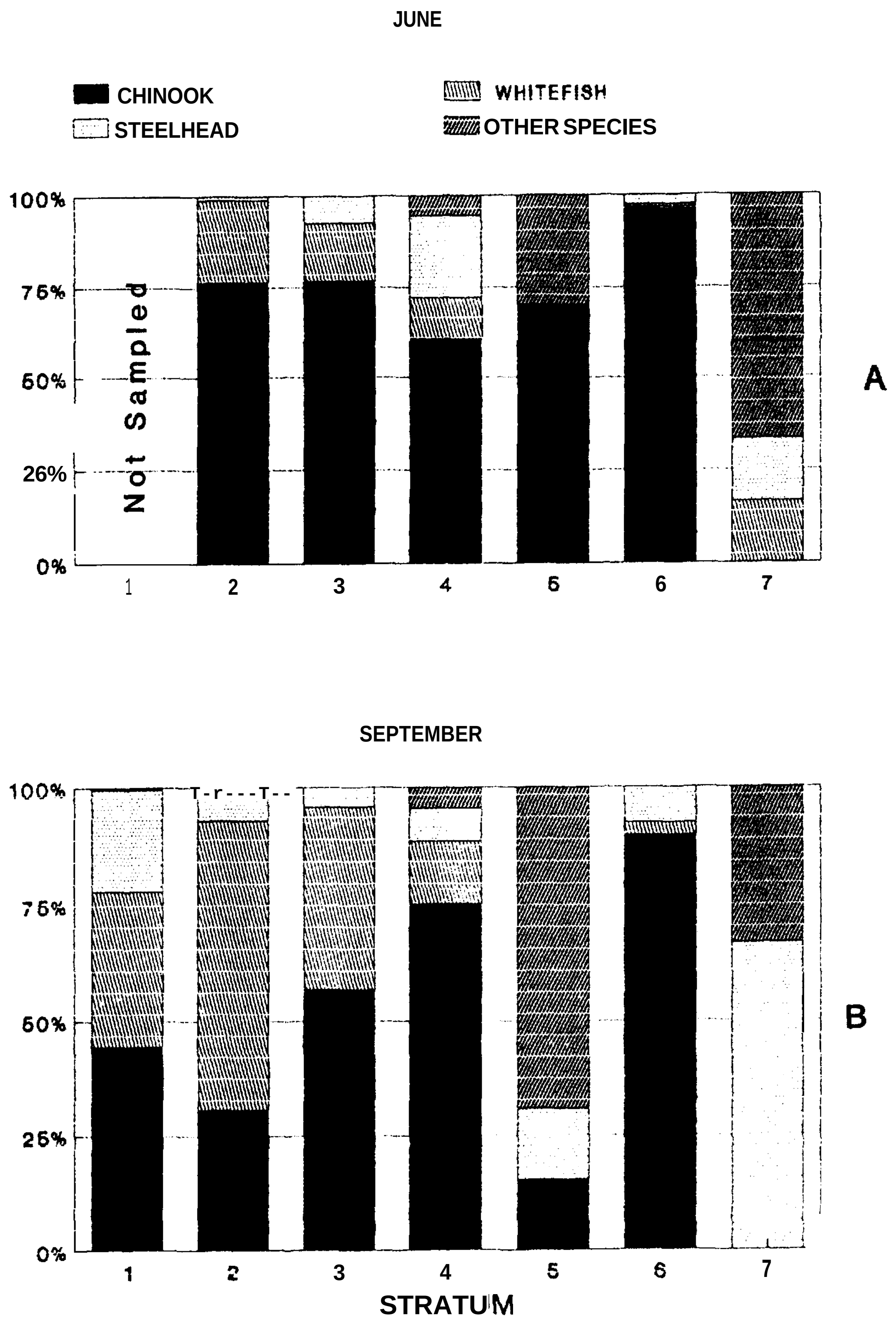

Figure 8. Relative abundance of fish spec .es by strata in June and September, 1989, Yankee Fork of the Salmon River.

Table 3. Mean and standard error of juvenile chinook salmon during June and September sampling sessions, Yankee Fork of the Salmon River, 1989.

	SESSION					
	June			September		
STRATUM	x	n	sd	x	n	sd
1	Not sampled			90.3	27	2.2
2	48.3	65	1.4	78.6	54	1.1
3	42.9	52	0.4	84.2	51	0.8
4	41.1	45	1.4	87.5	48	0.9
5	39.6	31	0.3	84.3	16	1.7
6	40.3	67	0.2	72.6	54	1.0
7	No fish observed			No fish observed		

32-75 mm. At this time, fish length distribution was centered in the 36-45 mm range, however, there was a smaller modal distribution in the 60-70 mm range (Figure 9a). This supports our contention that some larger hatchery fish moved from the ponds into mainstem habitat.

In September, fish lengths also differed significantly among strata ($P < 0.01$). Mean fish length was greatest in stratum 1 (90.3 mmj and smallest in the West Fork, stratum 6 (72.6 mm; Table 3). Mean salmon lengths were similar in strata 3-5 and ranged from 78.6 to 84.3 mm. As in June, emigration of pond fish may have contributed to the larger fish downstream in stratum 1. Unlike June, however, a fairly uniform modal distribution of fish lengths was observed in September ranging from 61-112 mm (Figure 9a).

khen fish lengths from coupled strata (1 and 2; 3 and 6; and 4 and 5) and the pond series are compared through the summer, we found that fish generally attained a similar mean length by September (Figure 10). Even though pond fish, and strata 1 and 2 fish were larger in June, much of this difference was eliminated by September (see Part 2 of this report for more detailed information on the growth of pond fish). Different rates of growth and size dependent outmigration likely contributed to the convergence of mean fish lengths among river sections. This is similar to patterns of growth observed in 1988 (Richards et al. 1989). In September, in strata 4 and 5, fish had the greatest mean length at 85.4 mm. Fish from the West Fork (stratum 6) and stratum 3, directly below the West York, were smallest at a mean length of 78.4 mm.

Stream Temperature and Flow

Water temperatures ranged from: 3.3 to 15.6°C during June; 4.4 to 20.6°C during July; 5.6 to 21.1°C during August; and 3.9 to 17.8°C during September.

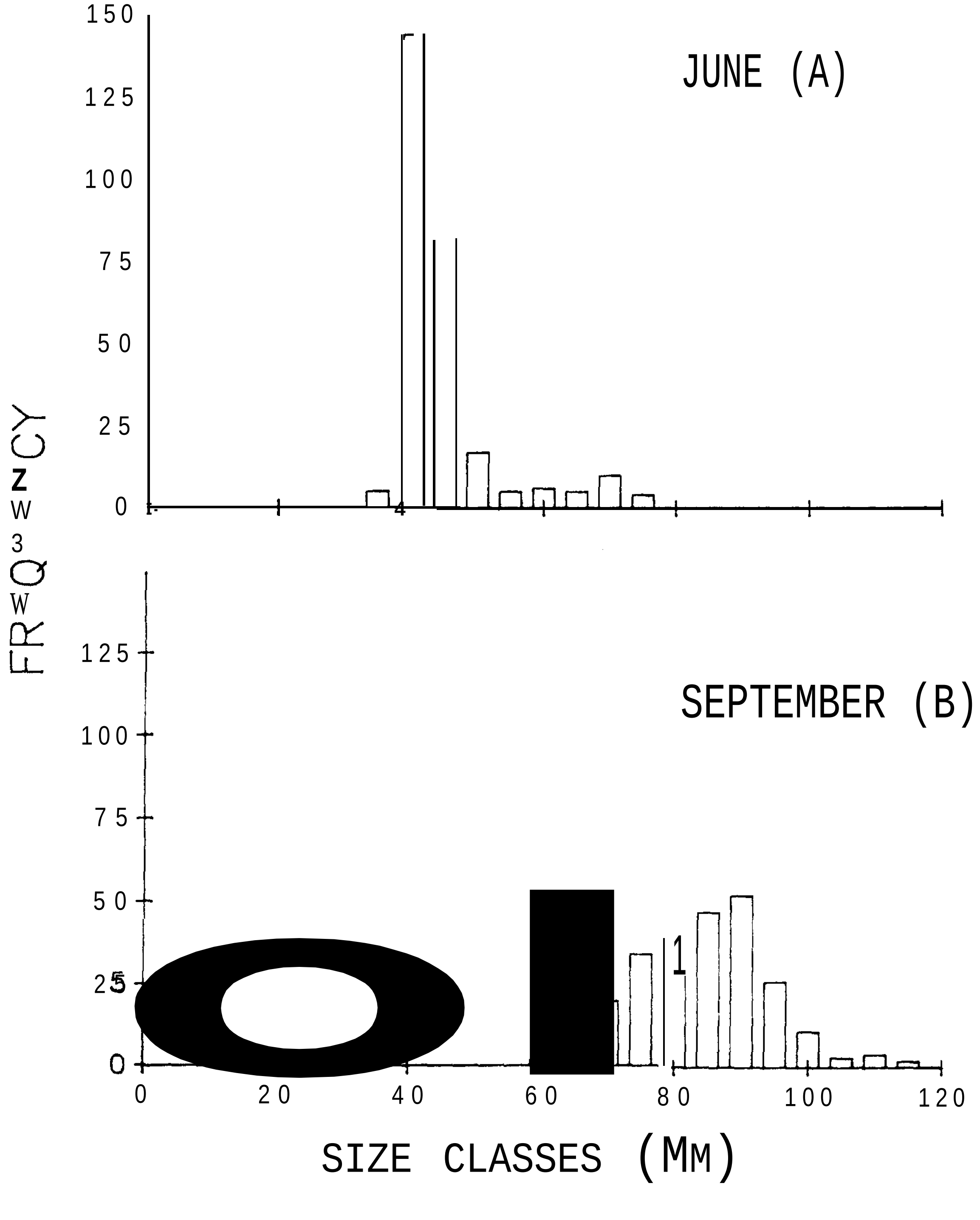

Figure 9. Length frequency distribution of age 0+ chinook salmon from all strata combined during June and September 1989, Yankee Fork of the Salmon River.

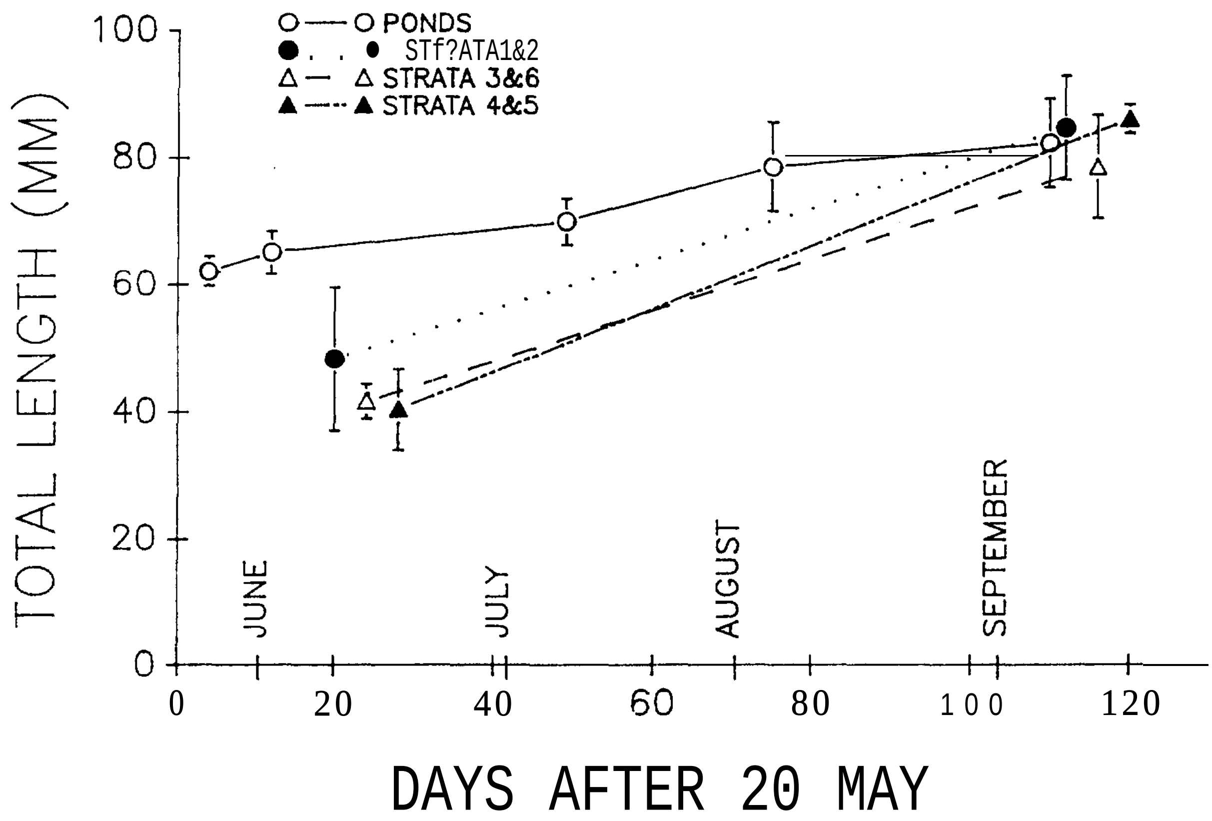

Figure 10. Mean and standard error of chinook salmon lengths from all pond series combined, stratum 1 and 2 (the river section adjacent and below the ponds), stratum 3 and 6 (the river sections directly above the ponds), and strata 4 and 5 (the upper Yankee Fork) during the summer 1989, Yankee Fork of the Salmon River.

Stratum 2, which encompasses much of the mined area and probably has the least amount of riparian cover, accumulated the most. degrees-days of all strata during the period of 13 June to 13 September (Figure llj. Further, the downstream strata (1 and 2) accumulated more degree-days than upstream Strata. This may have also been a contributing factor to greater early summer fish lengths observed in these strata.

September flow ranged from 1.7 m^3/second in strata 1 and 2 to 0.08 m^3/second in stratum 7 (Figure 12). These flows are higher than September 1988 flows which were influenced by two consecutive drought years (Richards et al. 1989). Stratum 3 flow was lower than that of stratum 4 (upstream) because of extensive subsurface percolation through much of the mined area.

Chinook Total Abundance and Redds

In June, we estimated a total of 7,314 age 0+ chinook salmon in our study reaches. This estimate is lower than the 9,156 June estimate of 1988 (Richards et al. 1989). Part of this difference may be explained by the contributions of progeny from stratum 4 egg-plantings in 1987. Stratum 2 and 6 (West Fork) contributed most to our total abundance estimate, at 1,386 fish (19%) and 4,159 fish (58%), respectively (Figure 13).

In September, our estimated chinook salmon abundance decreased to 6,087 fish. Excluding 1487, due to the influence of a large out-planting of hatchery fish, previous August/September parr abundance ranged from 12,847 fish in 1984 (Konopacky et al. 1986) to 38,084 fish in 1986 (Richards and Cernera 1987).

In 1989, stratum 1 and 6 were the greatest contributors to overall September abundance at 18 and 36X, respectively. Strata 2, 3 and 4 contributed smaller but similar percentages of fish to our September abundance

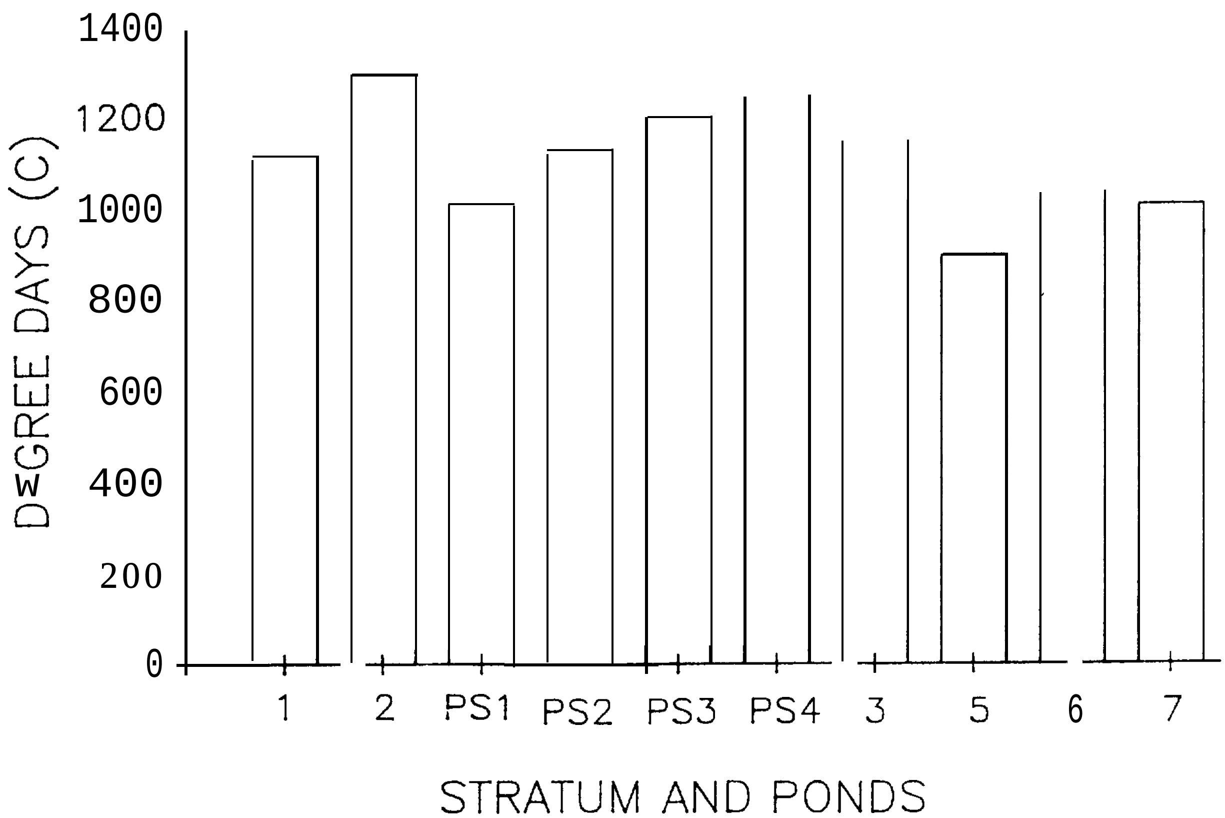

Figure 11. Accumulated degree days for strata and each pond series from 13 June to 13 September 1989, Yankee Fork of the Salmon River.

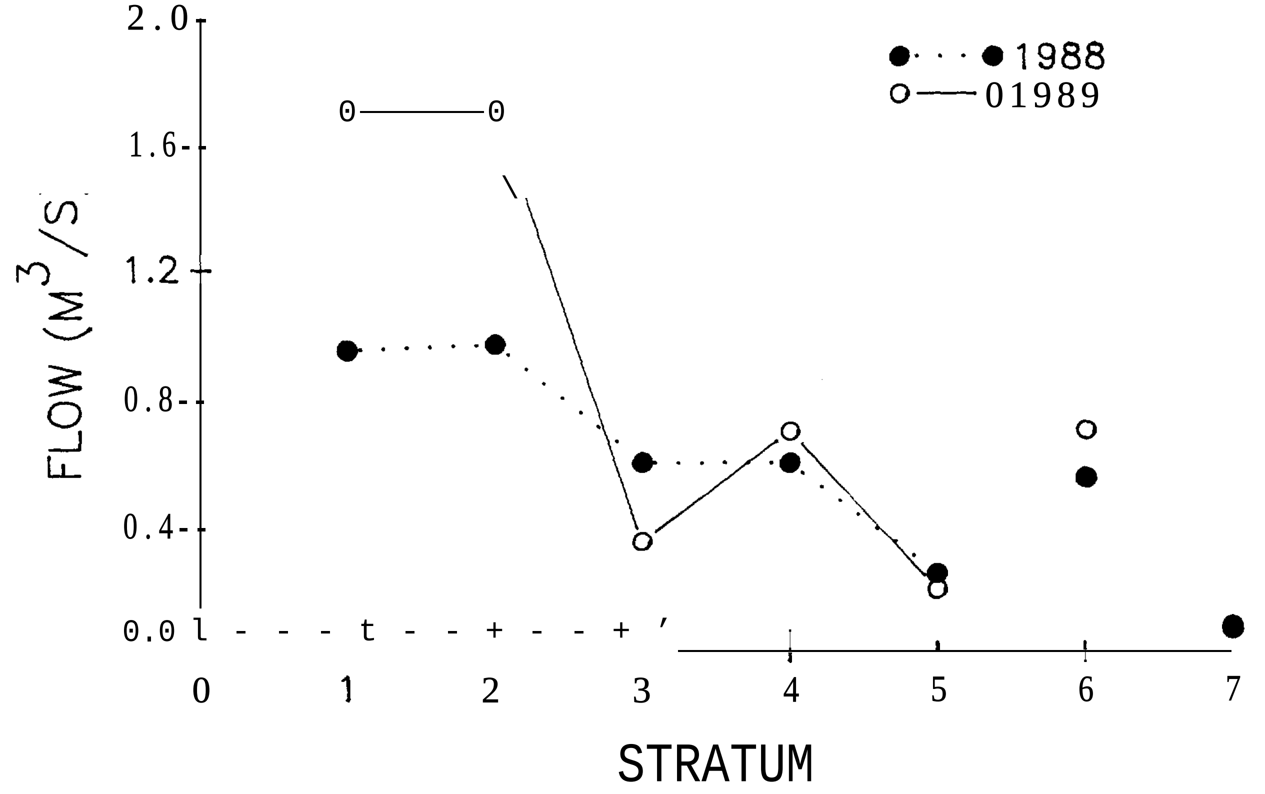

Figure 12. **Mainstem** Yankee Fork flows by strata **(1-5),** shown by line graph and tributary flows; West Fork, stratum 6; and Jordan Creek, stratum 7 shown as individual points for 1988 and 1989.

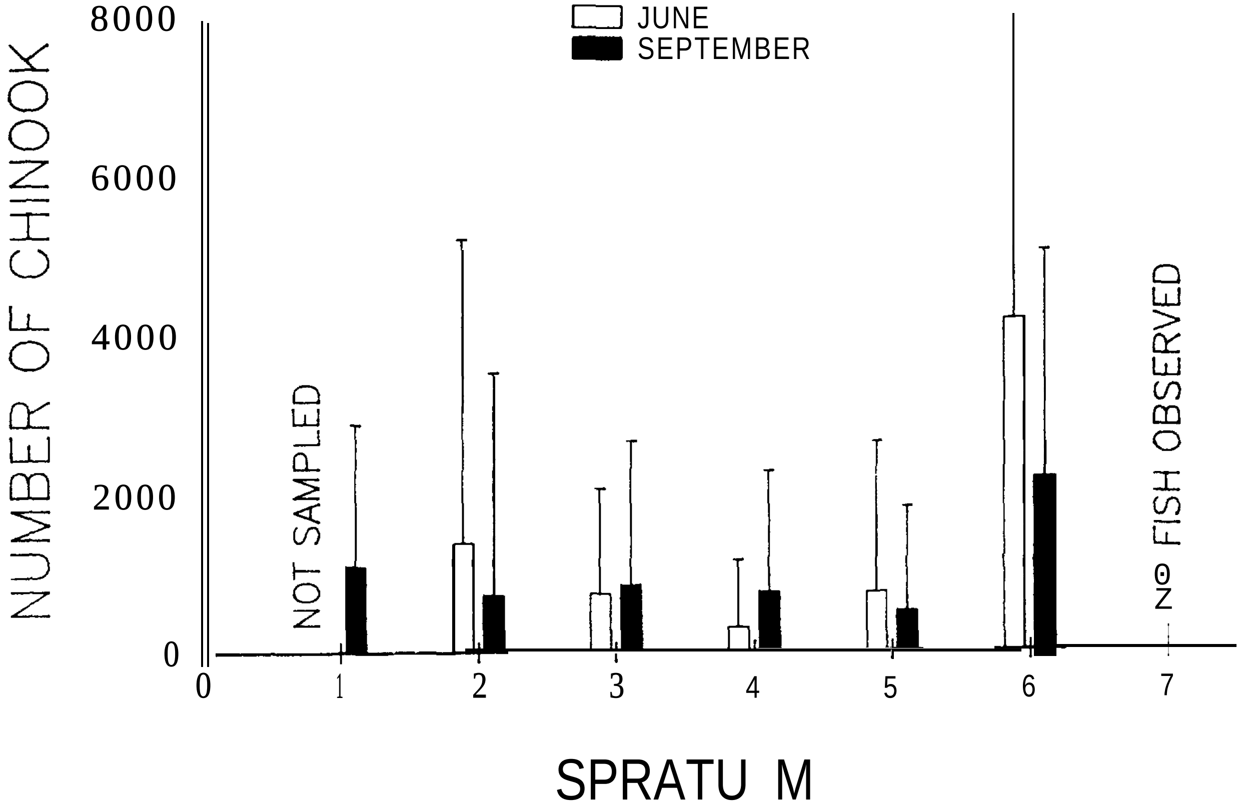

Figure 13. Total abundance of age 0+ chinook salmon during June and September 1989, Yankee Fork of the Salmon River. Error bars represent 95% confidence interval of mean.

estimate (Figure 13). Our **data** indicate the West Fork system's contribution to chinook salmon production within the Yankee Fork drainage is extensive.

Total smolt production in Yankee Fork is well below its potential. Using only West Fork as an example, our September estimate for parr was just under 2,200 fish. The potential smolt production from West Fork has been estimated at between 118,500 and 147,000 fish (BNI 1987; Keifer et al. 1989, respectively). Comparing our pre-smolt estimate with the estimated smolt potential component (ignoring the parr to smolt mortality component), the production in West Fork is less **than** 2% of its potential.

The number of redds were down in 1989 as compared to 1988 in Yankee Fork (Table 4). We counted a total of 16 redds on Yankee Fork proper; 6 redds were **observed** on the **West** Fork. Unlike 1988, all of the mainstem Yankee Fork redds that we counted in 1989 were located in strata 4 and 5. The 14 redds counted in 1988 were predominately located in strata 1 and 3. Upstream spawning may have been facilitated by the lack of a weir in lower stratum 4 in 1989. Since 1985 a weir in stratum 4 has been constructed in late summer to contain hatchery outplanted adults used for tribal ceremonial fisheries. However in 1989 this weir was not used. In 1988, 69% (31) of all redds counted occurred in the **West** Fork. In 1989, the West Fork experienced a considerable decrease in contribution to chinook spawning in the Yankee Fork as the total number of redds constituted only 27% of all redds counted (Table 4).

Table 4. Distribution of chinook salmon redds found in Yankee Fork of the Salmon River, Idaho for 1988 and 1989.

STRATUM	REDDS COUNTED 1988	REDDS COUNTED 1989	% OF TOTAL 1988	% OF TOTAL 1989
1	2	0	4.4	0
2	0	0	0	0
3	0	0	17.8	0
4	4	11	8.9	50.0
5	0	5	0	22.7
6	31	6	68.9	27.3
7	NS	NS	NS	NS
TOTAL	45	22	100%	100 %

NS = Not Sampled.

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ABSTRACT

Four series of off-channel dredge/settling ponds incorporated into the Yankee Fork of the Salmon River provided effective rearing habitat to hatchery-outplanted and naturally-produced juvenile chinook salmon, The lower three pond series were outplanted with chinook salmon fry at three levels: 7.5, 9.4, and 13.2 fish/m’ in pond series (PS) 1 to 3, respectively; PS 4 was left to be seeded by naturally-produced salmon, Initial post-stocking emigration was the major cause of salmon abundance reductions. We observed an 88-94% decrease in total numbers by July. Summer densities in stocked ponds were greatest in July, 0.47 to 1.56 fish/m’; PS 4 had a chinook salmon density of 0.73 fish/m’ at this time. Densities were lowest in September, ranging from 0.16 to 0.60 fish/m’. These late summer densities were much higher than mean fish densities from nearby river strata which ranged from 0.02 to 0.04 fish/m”. In September we estimated that PS 4 supported fish numbers equal to about 15% of the natural presmolt production in the 35 km of stream that we monitored. Mean fish length increases were greatest in pond series with lower densities. In July and August fish were larger in pond habitat; however, in September, fish were larger in channel habitat. This resulted from the movement of larger fish from pond to channel habitat as water temperatures decreased. Mean fish lengths in PS 1 to 4 during September ranged from 71.3 mm to 90.5 mm and compared favorably to river fish at 84.5 mm. Fish in off-channel pond series were in significantly (Pc 0.05) better condition than river fish, C = 0.95 and 0.87, respectively. Channel and pond bank habitat were most important to rearing chinook salmon during June when water temperatures were still low. In July and August open water habitat accounted for the greatest percentage of fish use. By September nearly 60% of all pond

series fish occupied channel habitat. Mean total invertebrate densities were significantly ($P < 0.05$) greater in pond benthos at 5,530 individuals/0.1 m^3 compared to pond plankton and channel benthos at 8 and 2,011 individuals/0.1m^3, respectively. Both pond benthic and plankton densities were greatest in bank and open habitat with cover. Proportion dietary overlap was greatest between channel fish and channel benthos at 0.66, and least between pond fish and pond benthos at 0.29. This suggests that much of the pond benthos present is not available as forage to chinook salmon.

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INTRODUCTION

Off-channel and tributary habitat use by juvenile coho salmon (Oncorhynchus kisutch) during the fall and winter freshet season in coastal systems is well documented (Bustard and Narver 1975, Cederholm and Scarlett 1981, Peterson 1982). Few studies though have investigated the importance of off-channel habitats to the rearing ecology of juvenile salmon in interior systems. Recently, however, early summer use of off-channel ponds by coho salmon in interior streams has been documented (Bustard 1986, Swales and Levings 198Yj. Flow regimes differ considerably between coastal and interior systems. The timing of movement by fish into pond habitat generally coincides with the spring and early summer high flow period for interior streams. These habitat types have also been shown to provide productive rearing habitat throughout the summer. This has partially been attributed to more conducive water temperatures and abundant invertebrate fauna (Swales and Levings 1989).

A paucity of information related to chinook salmon (O. tshawytscha) use of off-channel rearing areas exists. However, data from Swales and Levings (1989) do indicate that chinook salmon will use these habitats. Hard (1986) found that hatchery-outplanted chinook salmon fry in two small south-eastern Alaska lakes grew rapidly and had a high survival to the smolt stage. It is likely that off-channel pond habitat can be very important to salmon rearing and production if suitable main-channel habitats are limited.

Several miles of stream habitat in the lower Yankee Fork of the Salmon River have been severely altered by dredge-mining for gold since the late 1800's (Richards et al. 1989). Main-channel rearing habitat in the Yankee Fork was determined to be limiting to anadromous fish production (BNI 1987). This has contributed to the present depressed state of chinook salmon in the Yankee Fork.

To partially remediate for lost anadromous fish production, the Bonneville Power Administration (BPA) funded enhancement measures targeted at increasing rearing capacity in the Yankee Fork. Remnants of dredge mining, a large number of isolated off-channel settling ponds exist in Yankee Fork. Four series of these off-channel ponds were connected to the Yankee Fork via excavation of channels and construction of flow regulating structures. This new rearing area is expected to produce an additional 24,000 chinook smolts (BNI 1987). Construction was initiated in September 1987 and completed in the fall of 1988 (see Appendix A for a brief final summary of construction activities).

On 1 June 1988, the Shoshone-Bannock Tribes, in cooperation with the Idaho Department of Fish and Game, outplanted 50,000 juvenile chinook salmon in two of the four developed pond series. In 1989, with pond construction completed, 125,000 fry were outplanted into three of the four developed pond series. The unstocked pond series was used to assess the importance of this habitat type to naturally-produced fish.

Objectives of our 1989 program were: (1) to describe summer/fall habitat use by hatchery outplanted chinook salmon fry in pond series 1, 2, and 3 and by naturally-produced salmon in pond series 4; (2) to assess the effect of different stocking levels on chinook salmon densities throughout the summer; (3) to compare densities of fish using off-river pond and channel habitat versus main-channel Yankee Fork habitat; (4) to estimate total chinook salmon abundance in each pond series throughout the summer rearing period; (5) to evaluate growth of hatchery and naturally-produced fish using off-river pond and channel habitats; (6) to compare fish growth between pond and channel habitats; (7) to continue an assessment of the benthic and planktonic invertebrate community; and (8) to relate this invertebrate survey to feeding habits of chinook fry in pond and channel habitat.

STUDY AREA

The 9.6 kilometer dredge-mined section of the Yankee Fork is characterized by relatively wide, straight channels dominated by boulder and cobble substrate. The floodplain is covered with over 30 ponds of varying size, shape, and depth that are remnants of the dredging operation. Channels were developed between ponds within four distinct pond series (Figure 1). Each of the four pond series were then connected to the mainstem Yankee Fork, Check structures were constructed within the channels between some ponds to permit surface flow regulation.

METHODS

Available habitat within each pond series was quantified by delineating various habitat types on maps of the ponds and summing total area of each habitat type within a pond series. Pond shapes were traced from 1:24,000 air photos. In each pond series, eight different habitat types were characterized and delineated for each pond (Figure 2). Habitat types were based on; proximity of the habitat to the pond bank or to open water, the depth of that habitat (lm = shallow, >lm = deep), and cover availability within the habitat. In some instances deep water habitat had sparce vegetative cover on the bottom, this was not classified as cover since it appeared to provide minimal usable cover. Pond habitat types were then drawn to scale as accurately as possible using ground survey length and width measurements. Area totals for each pond habitat type within a pond series were produced using planimetry.

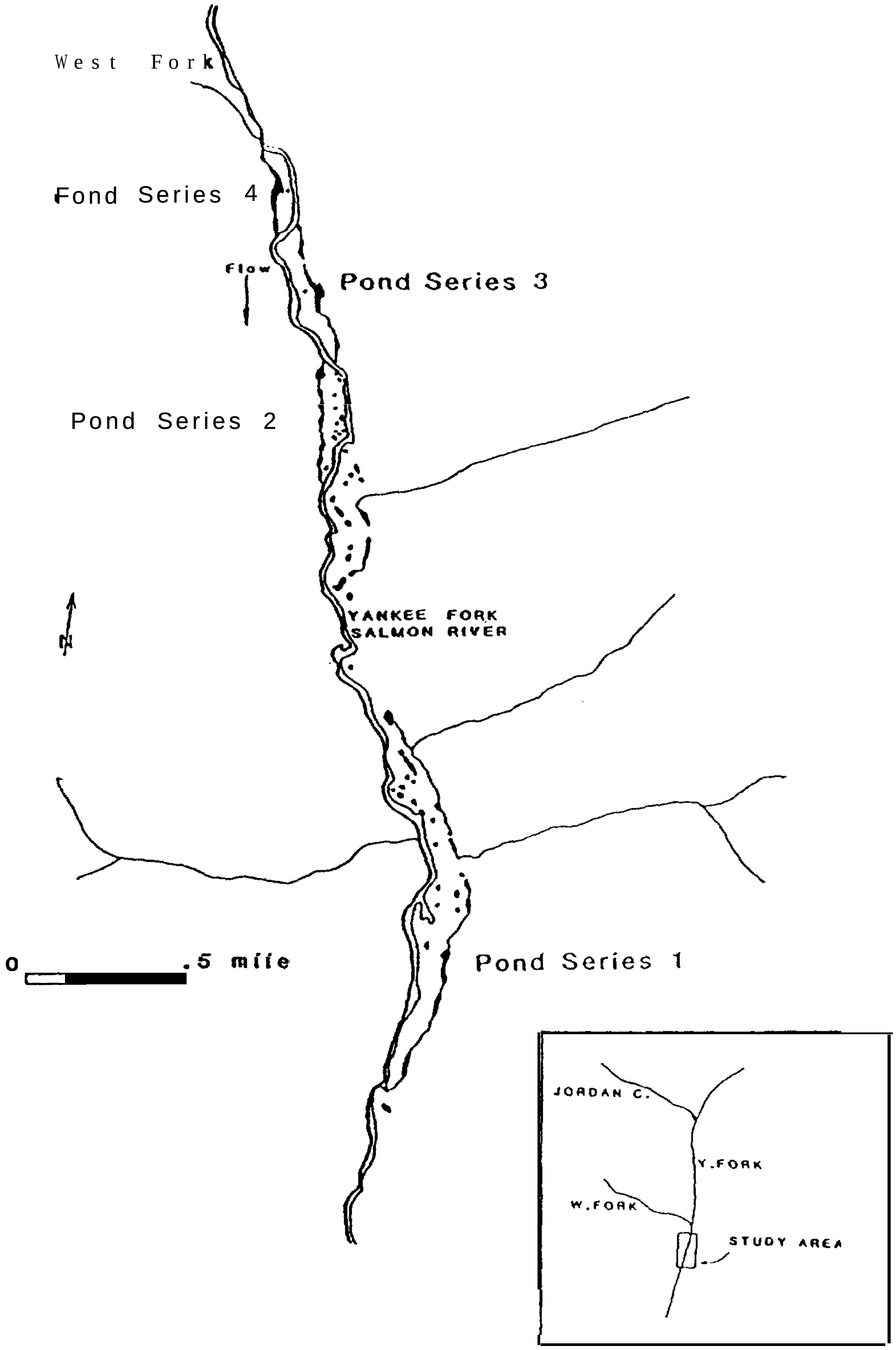

Figure 1. Study area and pond series locations, Yankee Fork of the Salmon River, Idaho, 1989.

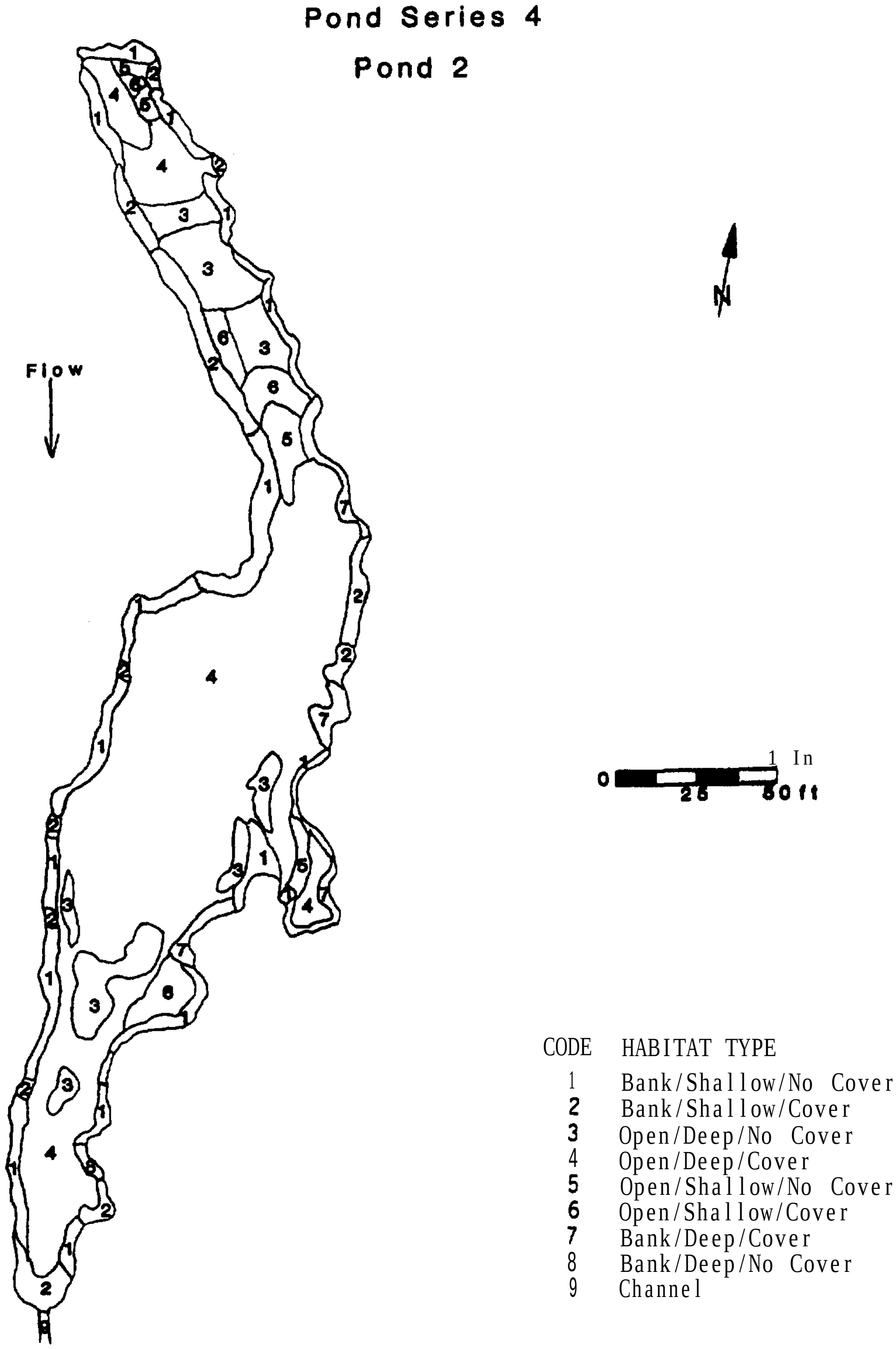

Figure 2. Habitat types contained within pond 2 of pond **series 4,** Yankee Fork of the Salmon River, 1989.

All available channel habitat was quantified using ground survey techniques (i.e., lengths and widths of pool and riffle habitat types).

Maximum and minimum water temperatures were recorded weekly from 30 May to 6 September in all four pond series at three to four different pond locations using Taylor "max-min" thermometers. For each pond series a weekly maximum and minimum temperature was calculated from individual thermometer readings. Degree-days by week were calculated using methods outlined in part 1 of this report. We also monitored salinity, conductivity, and dissolved oxygen in June, July, and August. Measures were taken in pond, channel, and river sites using YSI portable meters.

On 23 May, we outplanted about 125,000 chinook salmon fry (Sawtooth hatchery) into the uppermost pond of pond series 1, 2, and 3. Initial stocking numbers and densities were: pond series 1, 35,000 fish at 7.5 fish/m^2; pond series 2, 30,000 fish at 9.4 fish/m^2 and; pond series 3, 60,000 fish at 13.2 fish/m^2. No fry were planted into pond series 4 so that we could evaluate the use of this off-channel habitat by naturally-produced salmon. Furtner, in pond series 3, we tried to prevent post-stocking emigration of fish for three weeks with flashboards at the pond outlet check structure. We later discovered that a gap in the bottom flashboard permitted considerable aownstream movement of fish.

Fisn habitat use was monitored once a month from June to September during the first week of each month. We enumerated fish by habitat type using snorkel observations in the ponds and electrofishing technique in the channels. Electrofishing (UC) was conducted in two to three representative sections of channel within each series; each section contained at least two pool/riffle sequences. Channel sections were blocked with seines and densities calculated using the Zippin (1958) multiple step (3-pass) depletion method. Chinook salmon abundance for channels within a series was estimated using the Leslie estimate technique outlined in Everhart and Youngs (1981). We did not separate channel habitat out by cover components since this could not accurately be discerned by electrofishing.

In several small shallow ponds that had no cover, fish were enumerated by one person equipped with polarized lenses observing from the bank, In all other ponds, fish were enumerated by divers equipped with snorkel and mask. When pond widths were narrow enough to allow underwater observation to both banks from the center of the pond, one diver would approach the downstream end of the pond and slowly swim upstream, noting presence of fish and the habitat type occupied (e.g., southern portion of pond 1, pond series 4, Figure 2). In wider pond segments, two divers would enter the downstream end of the pond segment and swim upstream parallel to each other in "lanes" (Platts et al. 1983). Each observer only counted fish in his lane, Lane width was dictated by underwater visibility (the maximum distance that the diver could recognize an object the size of the smallest fish). In extremely large sections of certain ponds (e.g., the center of pond 2, pond series 4, Figure 2), after the divers moved upstream for a known distant they would leave the bank area and count fish in a lane across the open body of water to the other side of the pond.

In all pond series most habitat types were completely snorkeled. The total abundance for each of those habitat types was the summation of all the fish observed in that habitat. If a habitat type was only partially sampled, our abundance estimate for that habitat type was extrapolated for the entire area of that habitat present. Thus, total fish abundance within a pond series was estimated by summing the total and extrapolated fish counts for each habitat type.

Age 0+ chinook salmon density estimates for the eight pond habitat types and channel habitat were lumped into three basic habitat groups; pond bank, pond open, and channel habitats. Both bank and open water habitats were further classified into cover and no cover components. Cover was provided by boulders, woody debris, algae, and macrophytes. Density means were compared among habitat types (bank, open, or channel) for each session, between cover types, and among sessions (June, July, August, and September) using analysis of variance (ANOVA). For all comparisons, mean density values for a given habitat type were derived from pooled density data points from each pond series. An Individual density value for a habitat type was derived by dividing chinook numbers for that habitat type within each pond by the area of that habitat component within the pond. We transformed (log base 10+1) density data prior to applying inferential tests, We set the alpa level at 0.05 as criteria for statistical significance.

During each sampling session, we collected total length (mm) measurements from approximately 50 chinook salmon in channel habitat for each pond series. Also, starting in July, we collected 50 fish from pond habitat in each series except PS 1 where pond morphometry precluded open water fish capture. We used ANOVA to compare fish lengths among series and between habitat type. Tukey's multiple range test was applied to detect which factor was responsible for a significant difference. We also calculated condition of fish in each pond series and stratum 2 of the Yankee Fork using the isometric growth equation (Everhart and Youngs 1981). Statistical comparisons (ANOVA) were made for all pond fish among sessions and between (two-sample t-test) pond and river fish collected in June and September.

The invertebrate community in pond and channel habitat from each pond series was sampled from 17-21 July. Plankton was sampled using a Wisconsin plankton net (320 mm diameter face opening). One sample constituted three horizontal tosses for a known distance in a specific habitat type. From this we could determine the volume of water column sampled, We sampled the water column in bank and open water areas with and without vegetation. Each sample was preserved in 10% formalin. In the ponds we sampled the benthos with a Ponar dredge (14.1 cm x 17.0 cm face opening) to a depth of approximately 10 cm. A minimum of six samples were taken in representative areas of open and bank habitat with and without cover. Contents of dredge samples were placed in a bucket and all large lumps of clay material were broken down to create a homogenous slurry. The slurry was then sieved to collect all debris and benthic organisms from the sample. Samples were preserved in 10% formalin. We also collected five Surber samples from channel riffle habitat in each pond series. Channel substrate was sampled to a depth of approximately 10 cm. In the laboratory we used a 30 power microscope to identify invertebrates to the lowest possible taxa. This was generally to genus for all orders except diptera, which we only keyed to family. We used analysis of variance to test the hypothesis that total invertebrate densities (volumetric) were the same among habitats for plankton and pond benthos samples, and among plankton, pond benthos, and channel benthos (all habitat types combined).

Chinook salmon guts were examined from fish collected in the afternoon from 17 to 20 July. Surber samples were collected from coincident riffles where fish were captured. We used electrofishing (DC) gear to collect 20 fish from channels within each pond series. We also collected 15 to 20 fish from pond habitat in each series, except PS 1, on 20 July by electrofishing and seining. Fish were sacrificed and fixed in 10% formalin. Stomach contents were identified to the lowest possible taxa in the lab, generally family. We removed all stomach contents from the foregut back to the first anterior flecture of the stomach. Once stomach contents were identified they were placed in a vial containing 70% ethanol and dried overnight at 56 C. We calculated the dry weight of each fish as 24% of the live weight (Elliot 1975). We then computed the percent relative dry weight of gut content to factor out the effect of fish size. A two-sample t-test was used to test the hypothesis that percent relative dry weight of chinook salmon gut contents was the same in fish from pond and channel habitat. We used an index of overlap (C_H) between diet and benthic invertebrate samples in the channel and between diet and benthic and planktonic invertebrate samples for pond habitat to indicate feeding electivity:

$$(1)\quad C_H = 2 \sum_{i=1}^{s}\left(r_i\ p_i\right) \Big/ \left(\sum_{i=1}^{s} r_i^{2} + \sum_{i=1}^{s} p_i^{2}\right)$$

where C_H is the overlap coefficient, s is number of food categories, r_i is the proportion of total stomach content sample contributed by food category i, and p_i is the proportion of total Surber, Ponar, or planktonic sample contributed by food category i. C_H varies between 0 (no categories in common) and 1 (identical proportional composition) with overlap coefficients 0.60 indicating significant overlap (Zaret and Rand 1971).

RESULTS

Physical Evaluation

Pond surface area among the four pond series is much more similar than channel surface area. Total pond surface area is 3,130 m^2 (.77 acres) in series 1, 2,177 m^2 (.54 acres) in series 2, 2,921 m^2 (.72 acres) in series 3, and 2,836 m^2 (.70 acres) in series 4. Channel surface area ranged from 400 m^2 (PS 4) to 1600 m^2 (PS 3) (Table 1). The percent of total pond series water

Table 1. Habitat type classification and area measurement, pond series 1, 2, 3, and 4, Yankee Fork of the Salmon River drainage, September 1989.

HABITAT TYPE	CODE	PS 1 Area (m^2)	PS 1 % of Total	PS 2 Area (m^2)	PS 2 % of Total	PS 3 Area (m^2)	PS 3 % of Total	PS 4 Area (m^2)	PS 4 % of Total
Bank/Shallow/No Cover	(1)	507	10.9	228	7.1	505	11.1	349	10.8
Bank/Shallow/Cover	(2)	110	2.4	294	9.2	419	9.2	167	5.2
Open/Deep/No Cover	(3)	1013	21.8	815	25.4	67	1.5	287	8.9
Open/Deep/Cover	(4)	825	17.8	396	12.4	658	14.5	1501	46.4
Open/Shallow/No Cover	(5)	607	13.1	240	7.5	349	7.7	349	10.8
Open/Shallow/Cover	(6)	30	0.6	176	5.5	656	14.5	117	3.6
Bank/Deep/No Cover	(7)	20	0.4	0	0.0	103	2.3	8	0.2
Bank/Deep/Cover	(8)	18	0.4	28	0.8	167	3.7	58	1.8
Channel *	(9)	1509	32.6	1026	32.0	1613	35.5	399	12.3
Totals		4639	100.0	3203	100.0	4537	100.0	3235	100.0

* Measured in June.

surface area constituted by channel habitat ranged from 12.3 to 35.5X in pond series 4 and 3, respectively. Component percentages for each pond habitat type (i.e., percent habitat availability) is presented in Table 1. Open-deep pond habitat generally made up the greatest proportion of available habitat. Detailed information on individual pond depths, elevations, and water volumes is given in Reiser and Ramey (1987).

Accumulated degree days throughout the summer were greatest in pond series 4 at 1,246 degree days (Figure 3). Accumulated degree days were most similar among pond series in the month of June. At this time surface water temperatures were largely influenced by runoff. Pond series 1 was the only series not connected to the Yankee Fork at the upstream end and was totally fed by sub-surface flows; this probably accounted for the lower number of accummulated degree days in this series by summer's end, Pond series 4 averaged the greatest number of degrees per day throughout the summer at 12.5° C. However, this is still lower than the 13.9°C accumulated per day throughout the summer in stratum 2 of the Yankee Fork. Water temperatures within pond series ranged from a low 2.2°C in June to a high of 22.2°C in August .

Even though dissolved oxygen decreased from June through August levels never dropped below 7.0 mg/l, and were generally never less than 1 mg/l of measured river values. Dissolved oxygen values in ponds of series 1 through 4 ranged from 8.8 to 10.2 mg/l in June to 7.1 to 7.7 mg/l in August (Table 2). Dissolved oxygen was generally higher in channel habitat compared to pond habitat.

Conductivity was low but consistent among pond series (Table 2). Conductivity was lowest in June (range 30-42 umhos) and highest in August (range 69-77 umhos). There was little difference in conductivity between pond

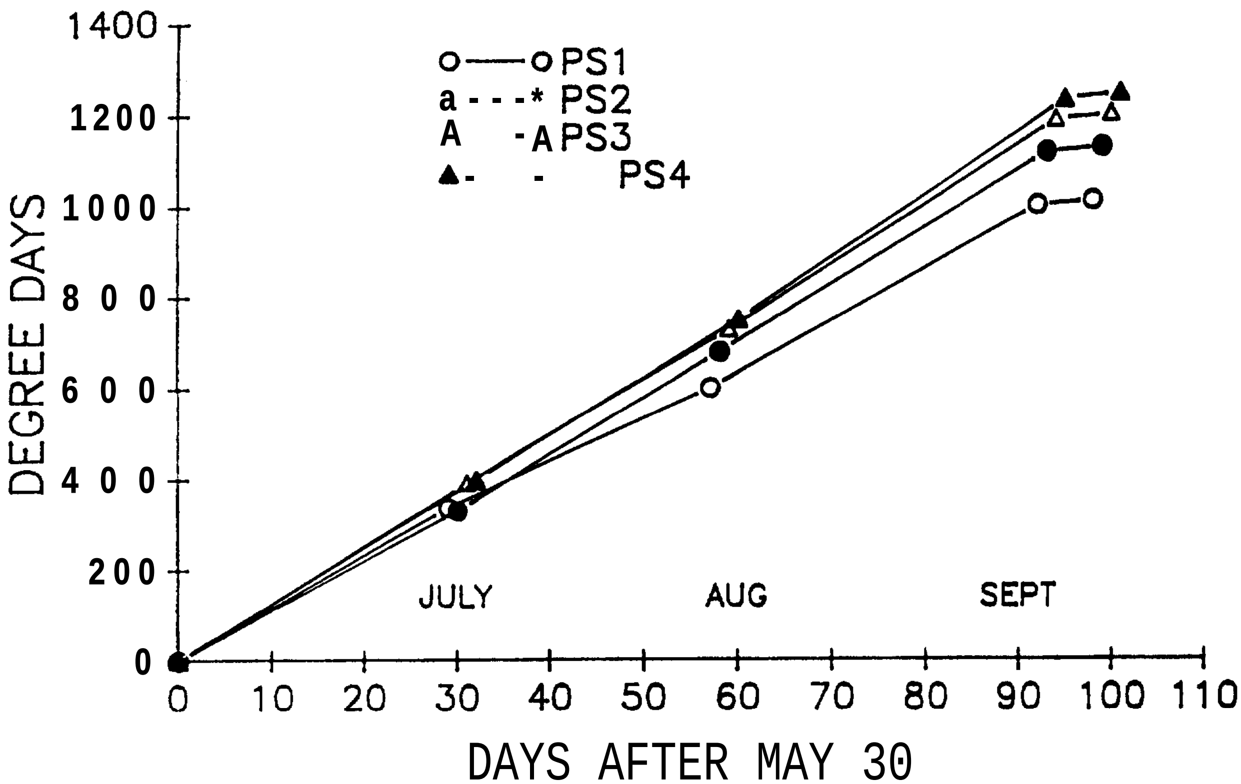

Figure 3. Cummulative degree days in pond series 1-4 from 30 May to 6 September, Yankee Fork of the Salmon River, 1989.

Table 2. Mean and standard deviation (parentheses) for dissolved oxygen and conductivity for each pond series (1 to 4) during June, July, and August 1989, Yankee Fork of the Salmon River.

DATE	AREA	HABITAT	Dissolved oxygen (mg/l)	Conductivity (umhos)
16 June	PS 1	Pond	8.8 (0.1)	42 (0.4)
		Channel	9.2 (0.2)	42 (0.3)
	PS 2	Pond	10.2 (0.6)	32 (0.2)
		Channel	10.1 (0.2)	30 (0.3)
	PS 3	Pond	9.9 (0.4)	32 (0.3)
		Channel	10.0 (0.7)	35 (0.3)
	PS 4	Pond	9.4 (0.2)	38 (0.2)
		Channel	10.4 (0.2)	35 (0.5)
	River		10.4 (0.2)	29 (0.1)
17 July	PS 1	Pond	7.5 '(0.3)	65 (0.1)
		Channel	8.0 (0.2)	62 (0.3)
	PS 2	Pond	7.5 (2.2)	67 (2.1)
		Channel	6.8 (0.8)	60 (0.0)
	PS 3	Pond	7.5 (0.5)	66 (4.1)
		Channel	7.9 (0.8)	70 (0.0)
	PS 4	Pond	8.1 (0.4)	62 (7.5)
		Channel	8.0 (0.1)	57 (7.1)
	River		8.9 (0.2)	49 (0.2)
8 August	PS 1	Pond	7.1 (0.2)	70 (0.0)
		Channel	7.1 (0.0)	70 (0.0)
	PS 2	Pond	7.5 (0.3)	73 (1.3)
		Channel	7.6 (0.0)	69 (0.0)
	PS 3	Pond	7.7 (0.5)	73 (3.5)
		Channel	7.9 (1.0)	77 (3.5)
	PS 4	Pond	7.6 (0.2)	71 (2.1)
		Channel	7.6 (0.2)	77 (4.9)
	River		8.5 (0.3)	66 (2.5)

and channel habitat during each month. Main river conductivity was always less than pond series values. The increase in conductivity throughout the summer may have resulted from decreased flows through the ponds from June to August.

Density and Abundance

Total chinook salmon density for all pond series combined was significantly ($P < 0.05$) greater in July compared to the other sampling periods (Figure 4a). Densities were greatest in July (range 0.47 to 1.73 fish/m′) and least in September (range 0.16 to 0.60 fish/m^3). Our density values in June were probably an underestimate since water temperature was still low and many fish were actually observed hiding in the substrates.

The highest pond series density by session was related to initial stocking levels. Pond series 3 was stocked at 13.2 fish/m^2 and had the highest observed densities through the summer (Figure 4a) with a September density of 0.60 fish/m′. Further, this is the pond series where we inhibited some post-stocking downstream movement for three weeks, Pond series 1 was stocked at 7.5 fish/m′ and had the lowest observed September density of 0.15 fish/m′. This pond series was the only one that did not have river access at the top of the series. This prevented downstream moving river fish from seeding pond habitat from the upstream end,

No hatchery fish were outplanted into pond series 4; all seeding of fish was from natural production. Densities in PS 4 were similar to chinook salmon densities in PS 2 from July through September (Figure 4a). We recorded a late summer density of 0.28 fish/m′ in this series. Pond series 4 is located just below the West Fork confluence, with the West Fork being the greatest producer of chinook salmon in the Yankee Fork System in 1989 (Part I of this report).

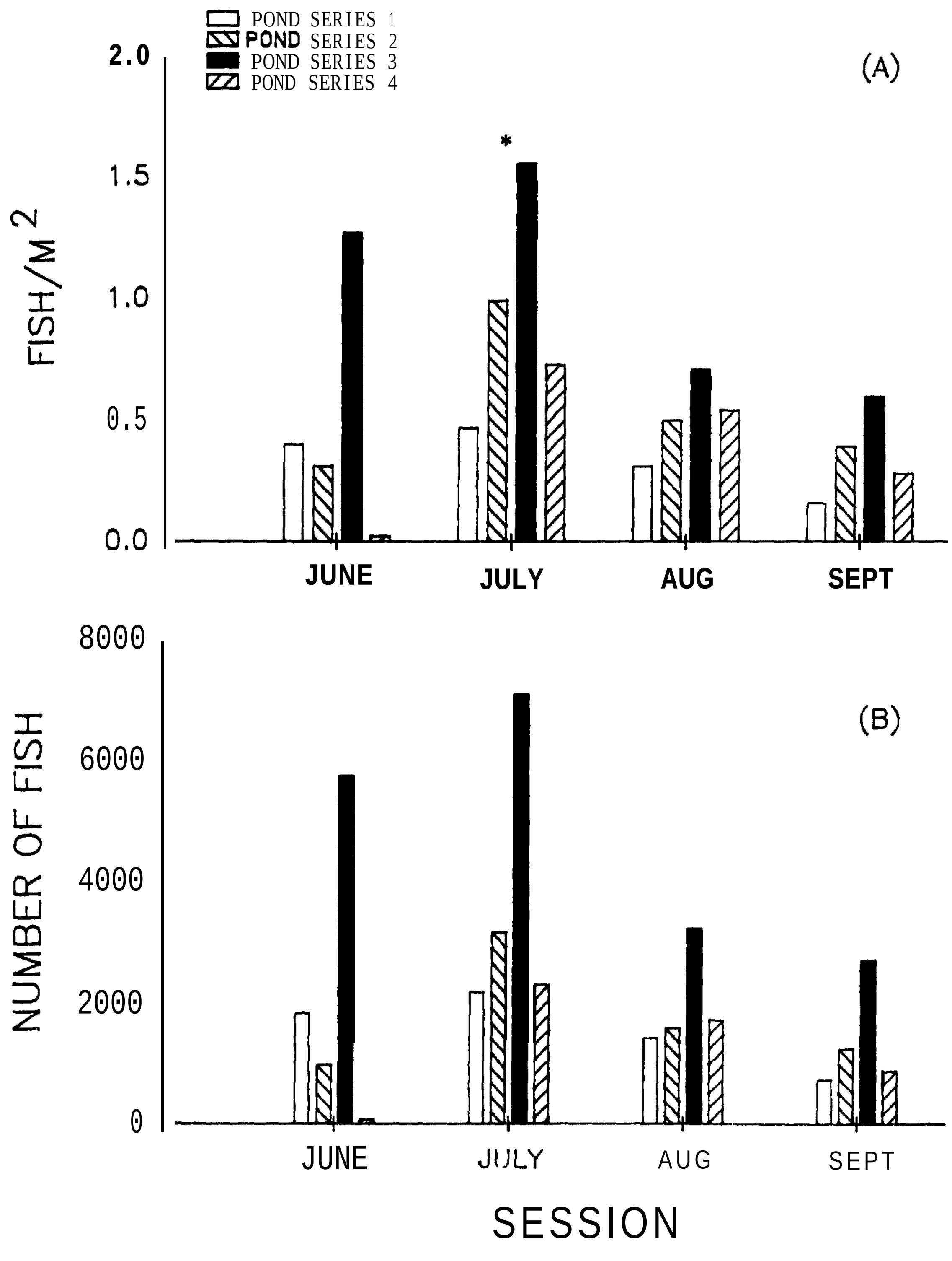

Figure 4. Total chinook salmon density (A) and abundance (B) from June through September in pond series l-4, Yankee Fork of the Salmon River, 1989. An asterisk above session densities indicates a significant difference from other sesssion densities.

In September total fish densities in each pond series were generally much higher than river densities. September chinook salmon densities ranged from 0.01 to 0.18 fish/m' in Yankee Fork strata 1 to 6 (see part 1 of this report). In stratum 2, where our study pond series are located, mean chinook salmon density was 0.02 fish/m". At the same time, pond series densities ranged from 0.16 to 0.60 fish/m" (Figure 4a).

Chinook salmon abundance by session, similar to chinook salmon density patterns, reached a maximum in July and a minimum in September (Figure 4b). Chinook numbers ranged from a high of 3,237 fish in PS 3 (July) to a low of 752 fish in PS 1 (September). We estimated total chinook salmon abundance (all pond series combined) to be 5,631 fish by September. This is a 95% reduction from our initial stocking number of 125,000 fish. Making a parr-to-smolt comparison, the September parr abundance is less than 25% of the potential smolt output of the ponds as estimated in the feasibility study.

In addition to chinook salmon, steelhead juveniles also used channel habitat within pond series. Very few steelhead were ever observed in pond habitat. Those steelhead observed were likely a combination of hatchery outplanted presmolts (age 1+) and wild fish (age 0+ steelhead). No age 0+ steelhead were observed in series channels during June. Mean density of age 0+ fish for all pond series increased to 0.05 fish/m^2 in July and continued to increase to 0.44 fisn/m^2 in September (Figure 5). Conversely, we observed the highest age 1+ steelhead density in June ((1.47 fish/m') with density decreasing to 0.07 fish/m^2 by September.

Habitat Preference

Altnough no significant differences were found (Appendix B), in general, cover was most important to chinook salmon in early and late summer. In June,

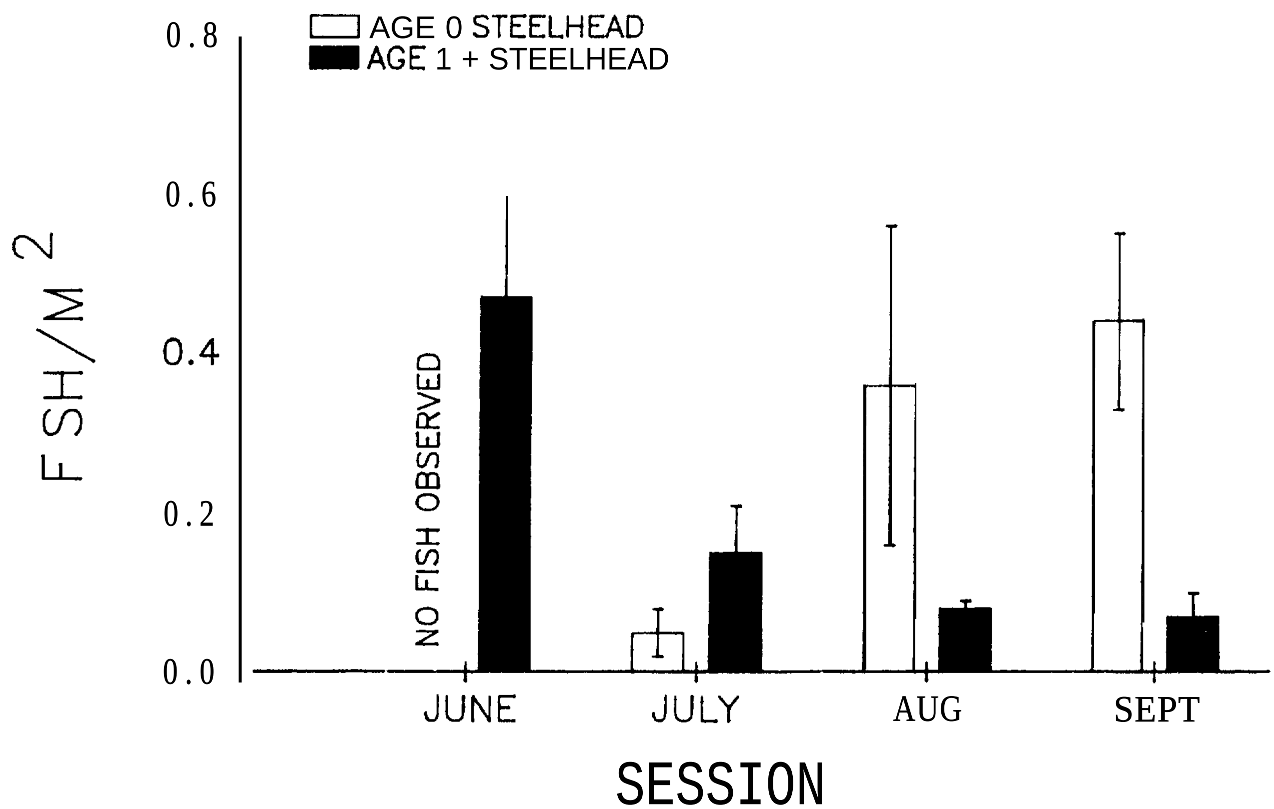

Figure 5. Mean densities of age 0+ and 1+ steelhead from June (session 1) to September (session 4) in channels for all pond series combined (n=8 per session), Yankee Fork of the Salmon River, 1989.

densities were greatest in channel habitat and pond bank habitat with cover, 3.57 and 1.67 fish/m′, respectively (Figure 6). August fish densities were greatest in open water habitat and bank habitat with cover. By September, as mean daily water temperatures (8.7-10.5°C) again decreased, bank cover and channel habiat maintained the highest fish densities (Figure 6).

Only in June in open habitat was there any deviation from use of cover in the early or late summer (Figure 6). Mean daily water temperatures were still low (6.5-7.2°C) at this time with many fish using substrate cover. Because of this, most fish observed in open water were only those in the water column. Fish that were using substrate cover at this time, in this habitat type, were difficult to enumerate,

Seasonal relative abundance among habitat types varied considerably throughout the summer (Figure 7). Over 50% of all chinook salmon (all pond series combined) used channel habitat in early and late summer, a rate of use disproportionate to the amount of habitat available (Figure 8). Cobble cover was abundant in channel habitat and apparently provided suitable cover conditions when water temperatures were low. In pond habitat the importance of bank areas and use rate versus availability decreased throughout the summer (Figure 7, 8). In July and August the greatest relative proportion of chinook salmon used open water pond habitat. Also during these two sessions fish use closely approximated habitat availabilty (Figure 8).

Chinook Salmon Lengths

Mean lengths of chinook salmon in the three supplementea pond series varied over the summer but were greater than naturally-seeded fish in pond series 4. During our June and July session, mean lengths of fish in hatchery-supplemented ponds (PS 1 to 3) did not differ (Figure 9, Appendix C).

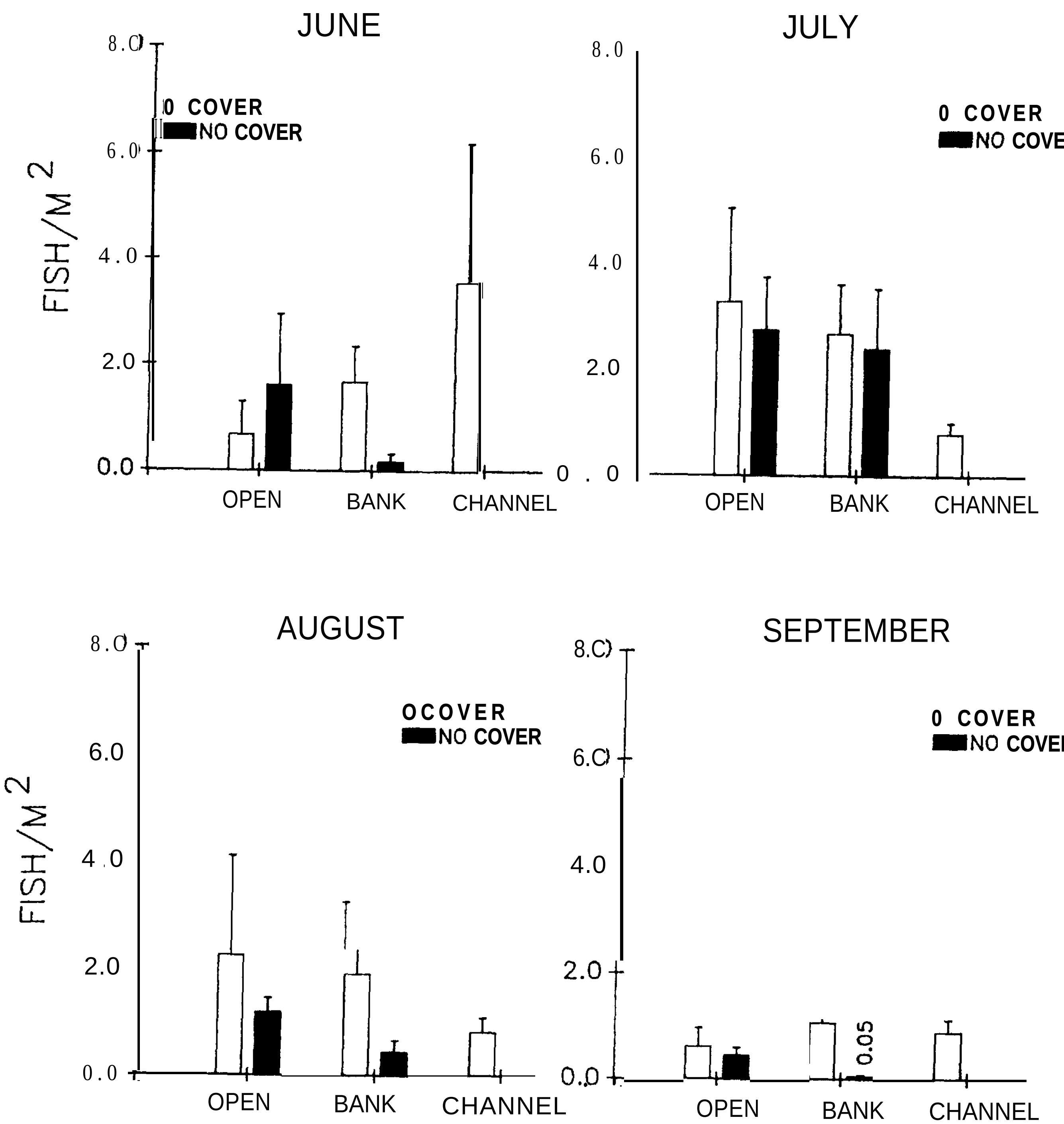

Figure 6. Mean densities of age 0+ chinook salmon among months and habitat types for all pond series combined, Yankee Fork of the Salmon River, 1989. Channel densities include both cover and no cover components.

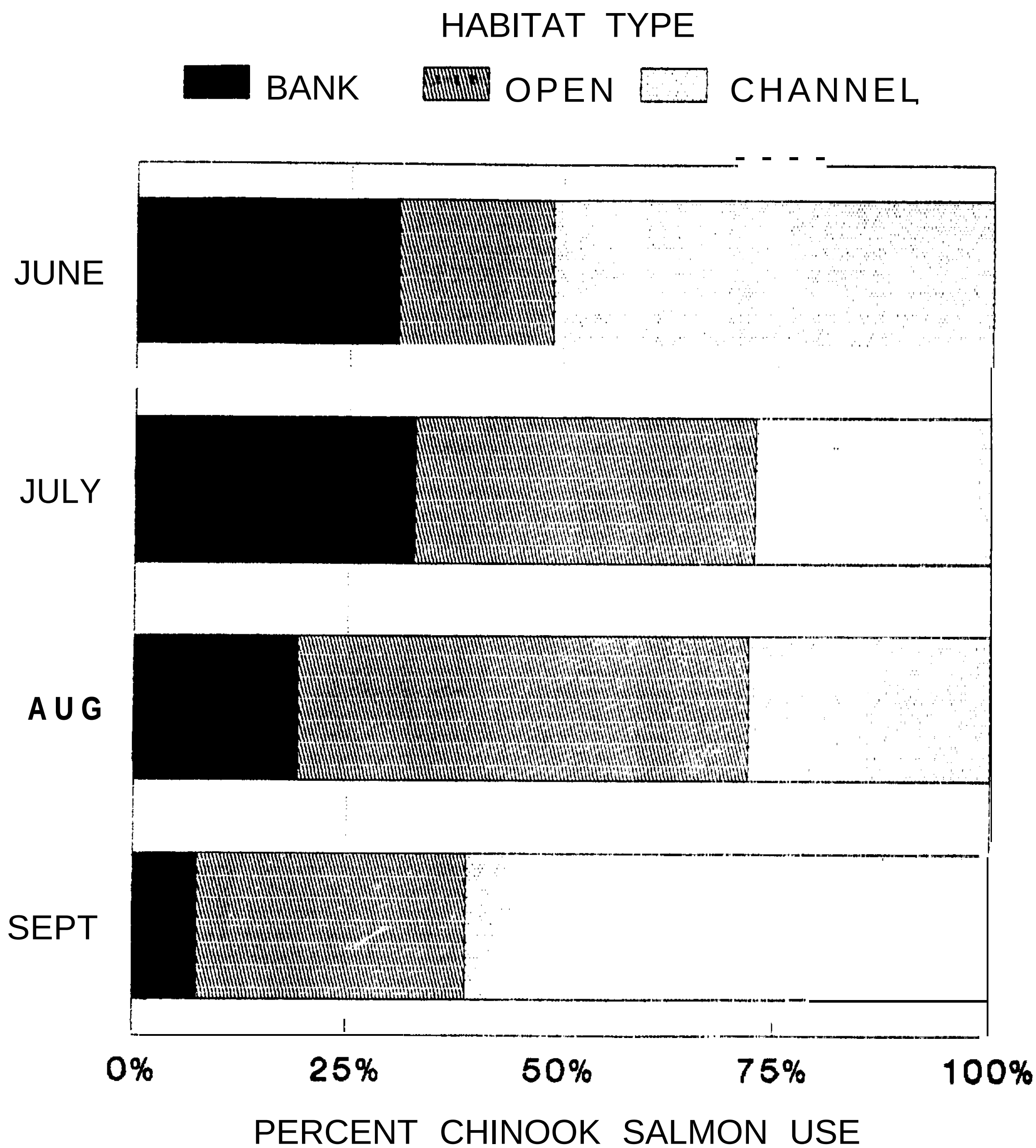

Figure 7. Relative proportion of chinook salmon using bank, open, and channel habitat during sessions 1 (June) to 4 (September) in pond series l-4, Yankee Fork of the Salmon River, 1989.

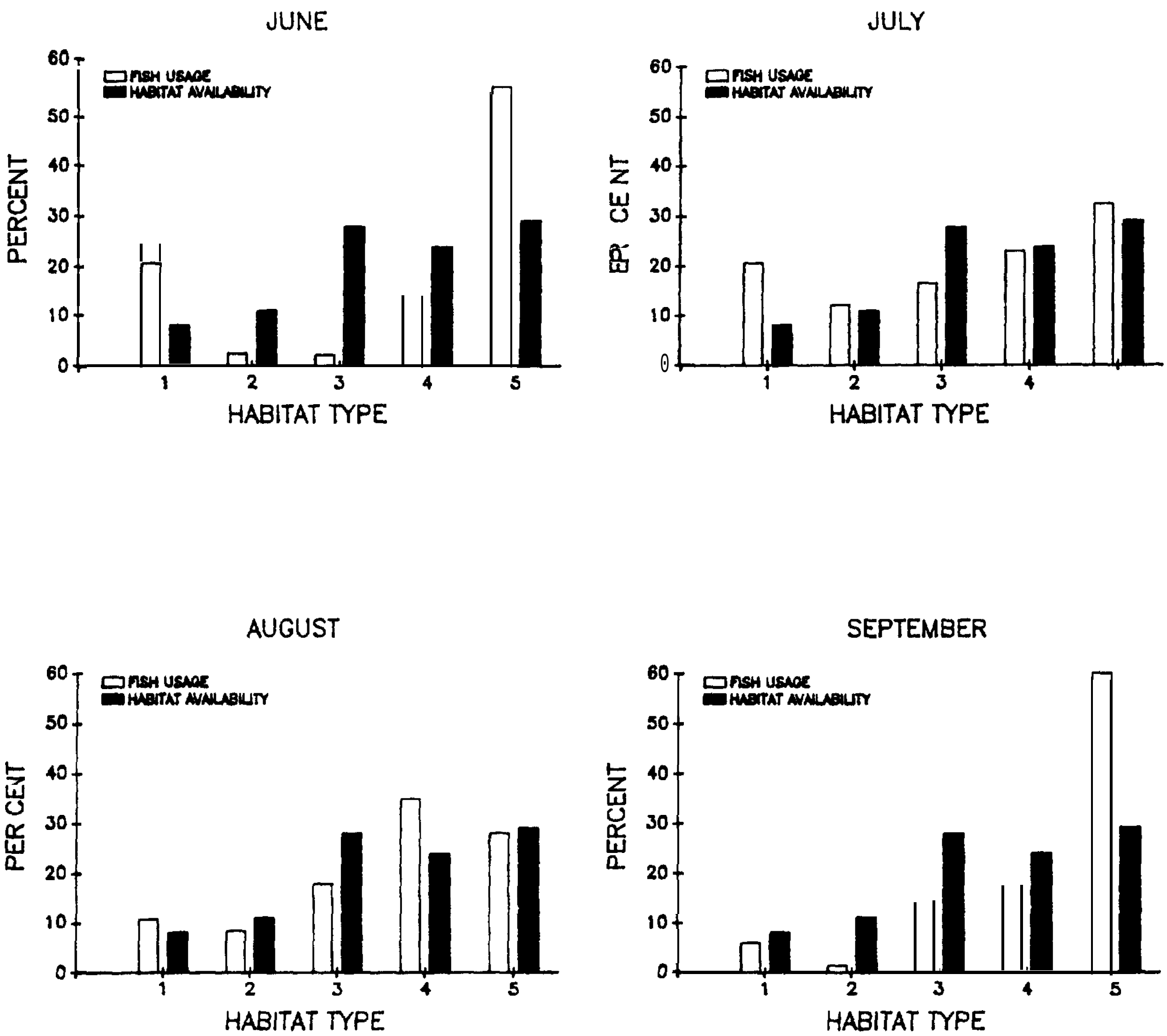

Figure 8. Percent chinook salmon use of five different habitat types (1=bank-cover, 2=bank-no cover, 3=open water-cover, 4=open water-no cover, and 5=channel) relative to habitat availability for all pond series from June through September, Yankee Fork of the Salmon River, 1989.

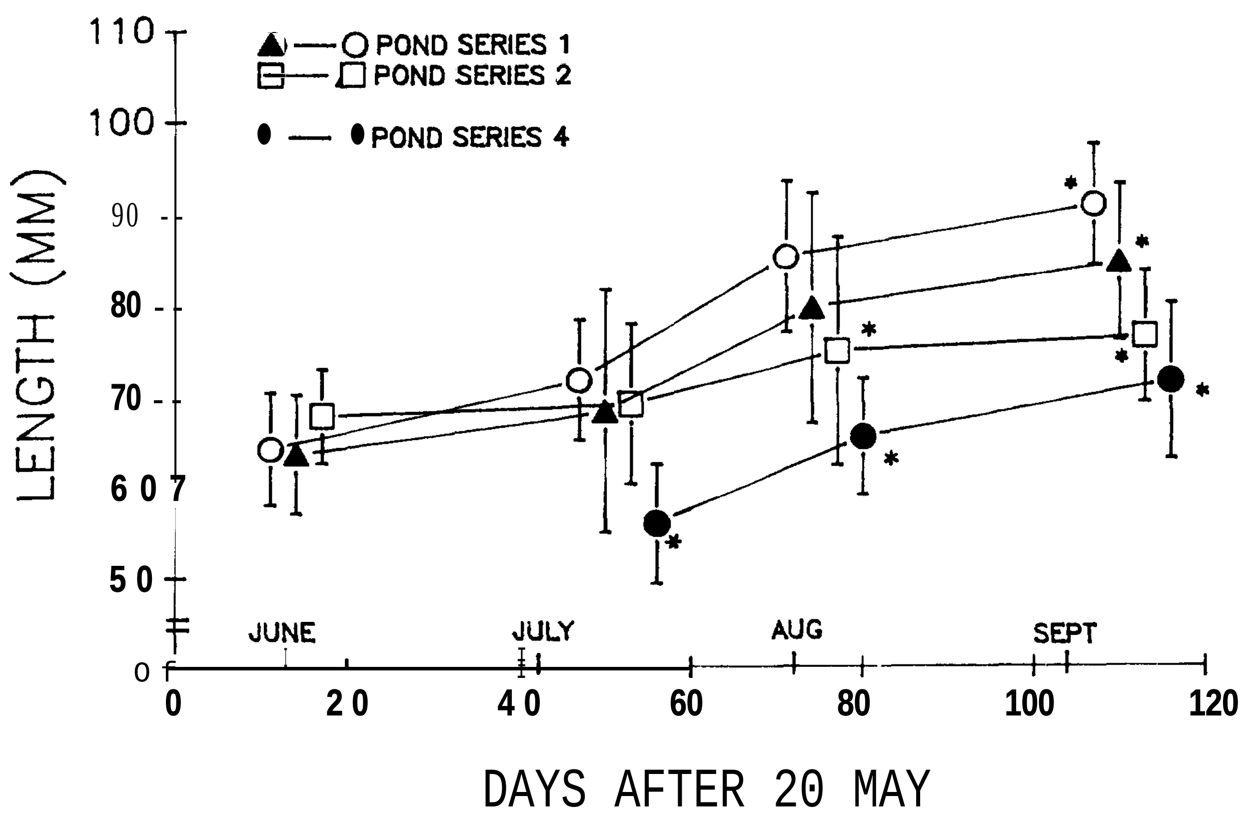

Figure 9. Increase in mean chinook salmon length from June to September in pond series l-4, Yankee Fork of the Salmon River, 1989. Error bars represent standard deviations, and an asterisk indicates a significant ($P < 0.05$) difference in mean length.

By August, mean lengths from PS 3 were significantly ($P < 0.01$) less from PS 1 and 2, and by September, all three pond series were significantly ($P < 0.01$) different.

Fish growth throughout the summer was least in pond series 3. This pond series maintained the greatest fish densities throughout the summer compared to the other three series (Figure 4). In PS 1, 2, and 4, the increase in mean fish lengths occurred at similar rates (Figure 9). Pond series 1 fish were significantly larger than all other pond series fish by the end of summer. At thls time chinook salmon densities were least in this pond series (Figure 4).

We found throughout the Yankee Fork system that growth was greatest where chinook salmon densities were least (Table 3). Stratum 1 and 2 fish (Yankee Fork proper) had the greatest increase in length (0.394 mm/day); chinook salmon densities were least here at 0.03 fish/m'. In PS 1 and the West Fork, densities were similar as were increases in mean length at 0.312 and 0.344 mm/day, respectively. We observed the greatest summer densities in PS 3 with these fish having the smallest mean length increase per day (Table 3).

We found that mean lengths of chinook salmon increased throughout the Bummer in channel habitat, but in pond habitat, after an increase from July to August, mean fish lengths decreased from August to September (Figure 10). In July and August we found that mean fish lengths in PS 3 and 4 were quite similar in pond habitat compared to channel habitat. In PS 2 at these times, fish were significantly ($P < 0.01$) larger in pond habitat. By September mean fish lengths in pond habitat either decreased or remained the same compared to August values in PS 2 to 4. In channel nabitat mean fish lengths increased from August to September and were similar to (PS 2 and PS 3) or actually greater than (PS 4) fish in pond habitat (Figure 10). This reverse in trend may be the result of pond fish moving from pond to channel habitat. This is

Table 3. Comparison of mean chinook salmon length increase by day from July to September (pond series fish) and June to September (river fish), and chinook salmon densities by month for each pond series and for June and September for river fish.

Location	Mean Length (mm) Increase by Day	Density (no/m')			
		June	July	August	September
PS 1	0.312	0.40	0.47	0.31	0.16
PS 2	0.264	0.31	0.99	0.50	0.39
PS 3	0.120	1.27	1.56	0.71	0.60
PS 4	0.260	0.02	0.73	0.54	0.28
Stratum 6	0.344	0.33	--	--	0.18
Stratum 1 & 2	0.394	0.02	--	--	0.03

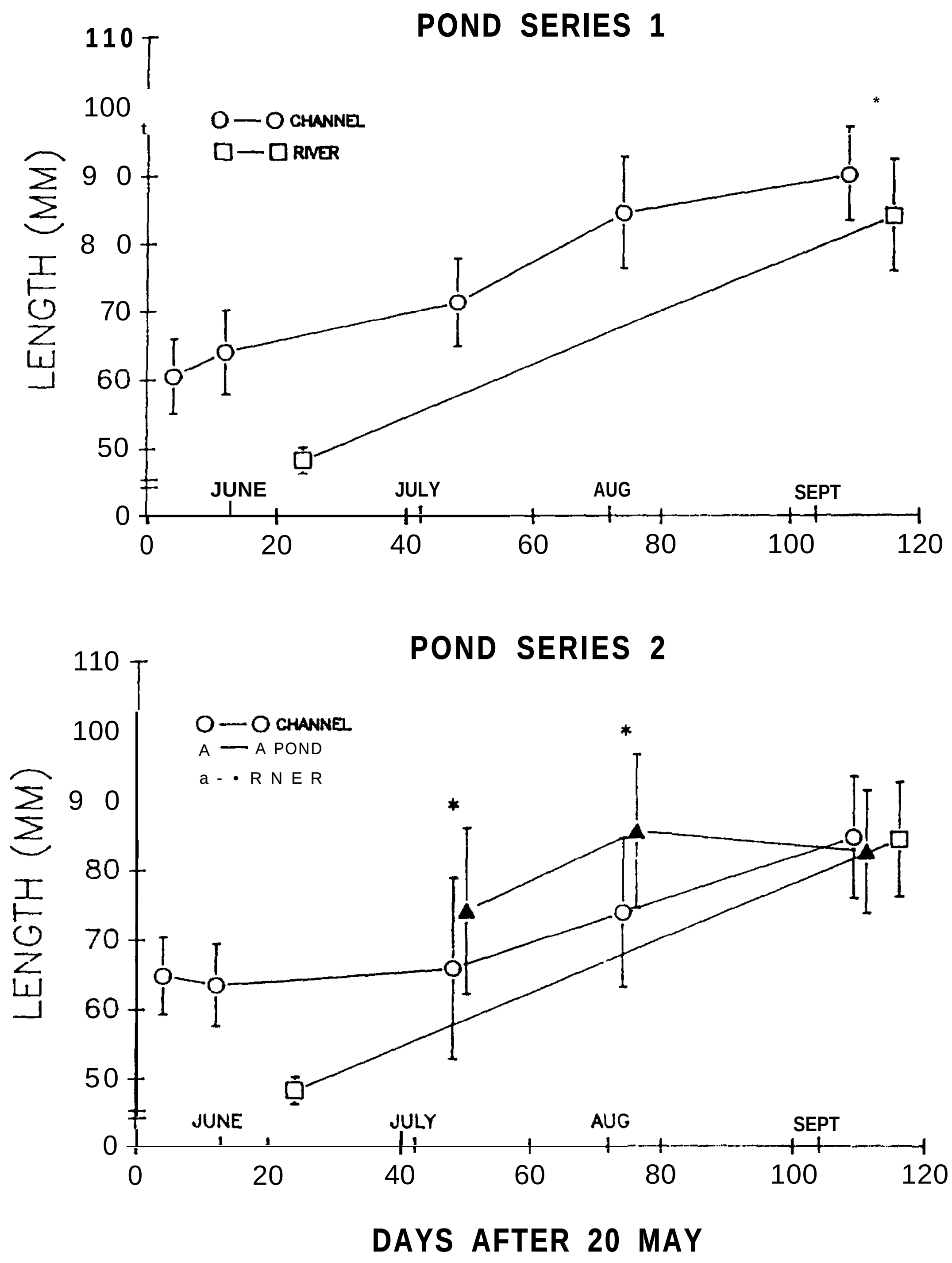

Figure 10. Mean lengths of chinook salmon in channel and pond habitat for pond series l-4 and river habitat 1 (strata 1 and 2) from June to September, Yankee Fork of the Salmon River, 1989. An asterisk indicates a difference between mean lengths. No pond fish were sampled in PS 1 due to sampling difficulties.

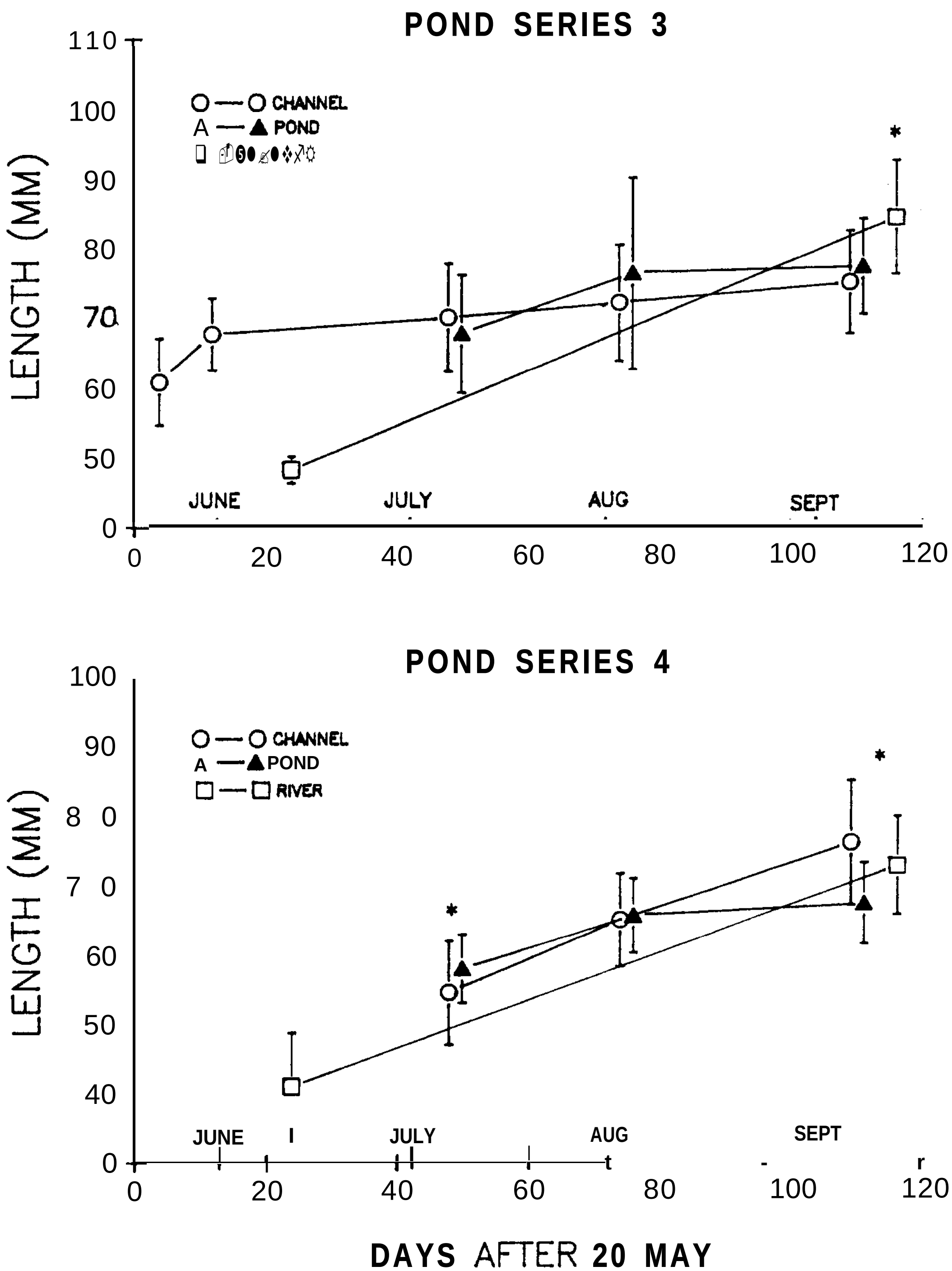

Figure 10. Continued.

supported by our data which suggests that proportionally more salmon used channel habitat in September (Figure 7, d). In each pond series except PS 3, fish lengths were similar or greater than Yankee Fork (strata 1 and 2) fish during September (Figure 10).

Chinook Salmon Condition

Condition factor for both pond series and river fish decreased from June to September (Figure 11). Mean fish condition values in June and July, 1.04 and 1.00, respectively, were significantly greater than fish conditions in August and September (Table 4). Pond and river fish (strata 1 and 2) were in the same condition in June (Figure 11). By September, however, fish from the ponds were in significantly ($P < 0.05$) better condition than river fish, 0.95 and 0.87, respectively. This information indicates that throughout the summer, fish that reared in off-channel habitats were in better shape than river fish by fall. Further, when we compared fish condition among all pond series in September, fish in PS 2 were in better condition than fish from the other three series.

Invertebrate Inventory

Invertebrate densities varied considerably among pond series with densities generally greatest in PS 1 and PS 4 for both pond benthos and pond plankton samples (Table 5). Further, benthic and planktonic samples from habitat with cover produced the highest total invertebrate densities.

For all pond series combined, total invertebrate densities were significantly ($P < 0.05$) greater in bank habitat with cover for both benthic and planktonic samples (Table 5). Also, mean total densities of invertebrates were significantly greater in pond benthos (5,530 invertebrates/$0.1m^3$)

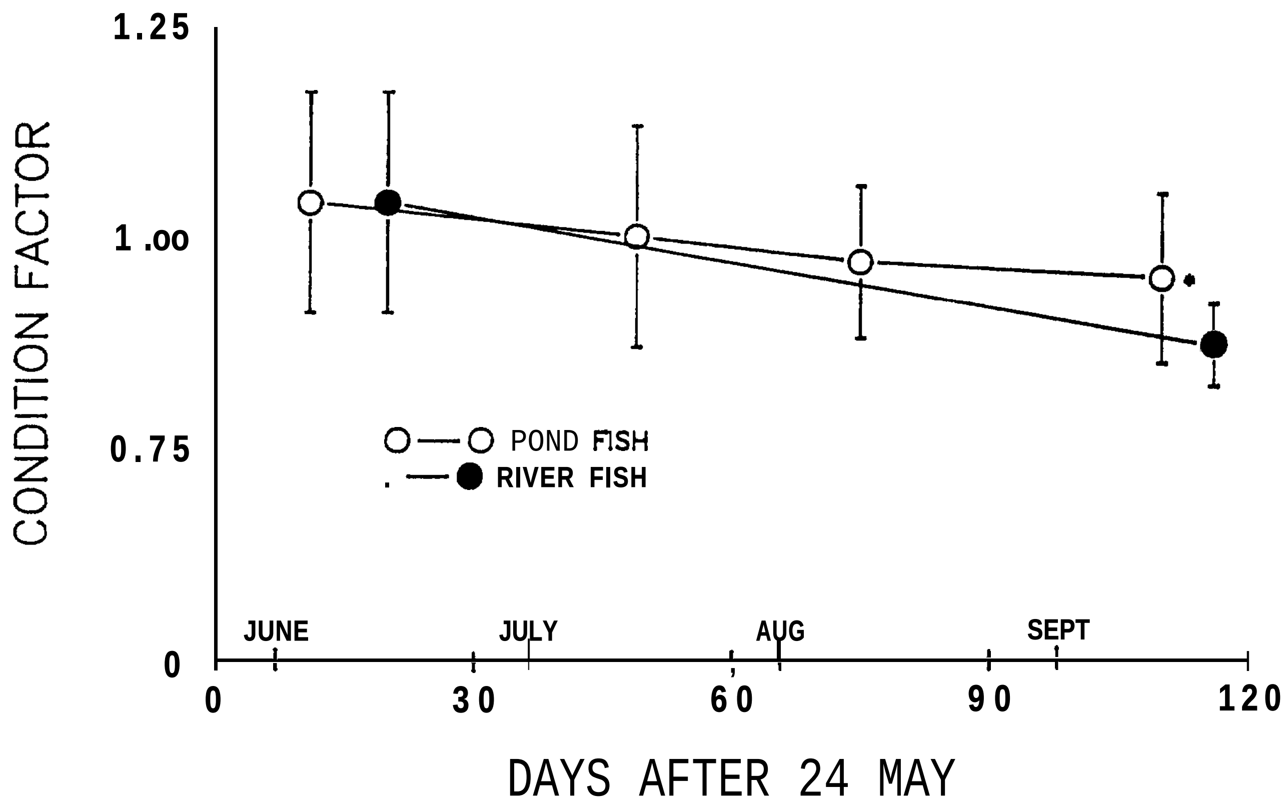

Figure 11. Mean condition factor of chinook salmon for all pond series fish (June-September) and for fish from strata 1 and 2 (June and September), Yankee Fork of the Salmon River, 1989. An asterisk indicates a significant difference between fish condition.

Table 4. Mean chinook salmon condition for pond series 1 to 4 from June to September, Yankee Fork of the Salmon River, 1989. An asterisk indicates a significant difference in mean condition.

Session	Pond Series 1	2	3	4	Mean
June	1.05	0.99	1.06	No Fish	1.04 *
July	0.95	1.02	0.95	1.04	1.00 *
August	0.95,	0.98	0.97	0.95	0.97
September	0.95	0.97	0.95	0.92	0.95

Table 5. Mean total invertebrate densities (no./0.1m^3) by volume and standard errors (parentheses) from pond series 1 to 4 in four different pond habitat types; 1) bank with cover, 2) bank without cover, 3) open water with cover, and 4) open water no cover sampled In the benthos and plankton, and in channel habitat, 17-21 July 1989, Yankee Pork of the Salmon River. An asterisk above a mean indicates a significant difference from all other means from that sample type.

Benthic and Planktonic Invertebrate Density by Sample and Habitat Type									
	Benthic Habitat				Planktonic Habitat				Channel Benthos
PS	1	2	3	4	1	2	3	4	
1	14431 (2319) n=6	2609 (1009) n=6	8385 (2173) n=6	1891 (863) n=6	13.4 (7.3) n=6	2.9 (0.6) n=6	7.3 (5.2) n=3	0.1 (0.06) n=3	1728 (569) n=5
2	7412 (3742) n=6	1071 (366) n=6	3407 (1213) n=6	1557 (285) n=6	4.4 (1.8 n=6	0.7 (0.3) n-6	3.0 (0.6) n=3	0.4 (0.1) n=3	1417 (302) n=5
3	4760 (1696) n=6	2688 (453) n=6	3463 (2315) n=6	4325 (822) n=6	4.6 (1.9) n=6	2.4 (0.9) n=6	5.6 (5.2) n=3	1.0 (0.8) n-3	1990 (505) n-6
4	12911 (5224) n=6	4310 (1732) n=6	5701 (2878) n=6	3587 (442) n=6	41.9 (15.3) n=6	2.0 (0.8) n=6	18.8 (16.9) n=3	0.4 (0.2) n=3	2000 (384) n-5
Totals	* 9878 (2614) n=24	2670 (542) n=24	5239 (1529) n=24	2840 (447) n=24	* 16.1 (5.1) n=24	2.0 (0.6) n=24	8.8 (4.6) n-12	0.5 (0.2) n-12	1784 (440) n=21

compared to pond plankton (7.6 invertebrates/0.1m^3), but not greater than channel benthos (1,784 invertebrates/0.1m^3).

We compared benthic and planktonic invertebrate densities in PS 3 and PS 4 between 1988 and 1989 samples and found no significant (P 0.05) difference. In 1989, benthic densities (5,534 invertebrates/0.1m^3) increased compared to 1988 densities (4,190 invertebrates/0.1m^3) reported by Richards et al. (1989). Plankton densites however, were nearly equal between 1988 and 1989 at 10.5 and 10.6 invertebrates/0.1m^3, respectively.

Dipterans and non-insect invertebrates (e.g., annelids and mollusks) constituted the greatest proportion of organisms from pond benthic and planktonic samples (Table 6j. For benthic samples from the four pond series these groups represented 63 to 81% of all organisms enumerated. In planktonic samples from all the pond series, these same groups represented 68-98% of all organisms enumerated. Slphlonuridae and Baetidae (Ephemeropterans), and Limnephilidae (Trichopteraj together represented 11%, 23%, 7%, and 29% of total pond benthlc invertebrate numbers in PS 1 to 4, respectively (Table 6). (Mean number of individual taxa by habitat type for each pond series are presented in Appendices D-F),

Ephemeropterans and Trichopterans, generally important forage constituents to juvenile salmonids, were better represented (Appendix F) and proportionally more abundant in series channel habitat (Table 7). These two orders constituted 37%, 48%, 28%, and 40% of the total invertebrate abundance in channel benthos from PS l-4, respectively. Chironomids were the single most abundance taxa in channel habitat (Table 7).

Table 6. Percent of identifiable invertebrate composition in plankton (pl), ponar (p2), and chinook salmon stomach (r) samples, and dietary overlap index for samples taken from pond series 1 to 4 pond habitat, Yankee Fork of the Salmon River, IS-21 July, 1989. Total number is the sum of all invertebrates from each sample type pooled. Categories within each order are for immatures unless otherwise indicated (Ad=Adult). Sample size for each sample type is given in parentheses.

	POND SERIES											
	1			2			3			4		
TAXON	pl(18)	p2(18)	r(O)*	pl(18)	p2(18)	r(15)	pl(18)	p2(18)	r(15)	pl(18)	p2(18)	r(13)
Ephemeroptera												
Siphlonuridae	1.4	0.1		8.8	0.2		1.0	2.8	24.1	15.2	1.1	2.3
Baetidae	3.9	0.4		7.5	0.2	29.1	4.5	0.6	4.3	6.0	0.5	1.2
Leptophlebiidae	0.6	0.1		1.3			0.8	3.0		0.9	18.1	
Ephemerellidae				0.2		2.3			5.2			3.5
Adult (unknown)						10.3			3.5			5.8
Trichoptera												
Limnephelidae	6.0	4.2		5.5	0.1	2.3	1.9	0.6	2.6	6.5	0.2	
Bracycentridae	0.1			–						0.1		
Lepidostomatidae	0.1		–	–				0.8		0.3		
Rhyacophilidae							0.1	0.1			0.1	
Hydroptilidae	0.1	0.1	–	–				1.1				–
Diptera												
Chironomidae	47.2	9.1		25.7	38.6	25.6	9.1	9.3	36.2	16.1	48.2	19.5
Chironomidae (Ad)						10.5			13.8			31.0
Ephydridae	0.2			1.5						1.4		
Ephydridae (Ad)			–	–		1.2						
Culicidae				1.5			0.3					
Ceratopogonidae	0.1			11.6	5.0		21.2			5.1	0.3	
Tabanidae		0.1	–	–	0.3			0.1				
Emphimidae	1.1	–					0.1					
Tipulidae		0.4		1.1	0.1		1.0	0.1				–
Tipulidae (Ad)			–	–		2.3						
Empididae			–	–		–	0.1	0.1				3.5
Hemiptera												
Corixidae	14.5	0.1		5.3	0.1		4.1			5.6	0.3	
Gerridae	0.2					1.2						–

Table 6. Continued.

	POND SERIES											
	1			2			3			4		
TAXON	p1(18)	p2(18)	r(0)*	p1(18)	p2(18)	r(15)	p1(18)	p2(18)	r(15)	p1(18)	p2(18)	r(13)
Coleoptera												
Dytiscidae		0.2	–	1.5	0.1	1.2	2.1	0.1	0.9	1.4	0.7	
Elmidae			–				0.1	0.1	0.9	0.3		
Haliplidae	0.1	0.2	–	0.6			0.7			0.8	0.1	
Odonata												
Aeshnidae			–		0.1				–	–		
Megaloptera												
Saliidae			–		0.6	1.2		0.6	–	–	0.3	
Annelida	3.7	71.8	–	0.6	38.9		1.4	24.2			11.3	12.6
Arachnida	12.3	0.4	–	1.5	1.1		2.8	0.4		18.1	0.4	
Hydracarina	3.8		–		0.1		0.1			0.9	0.1	
Copepoda	0.9		–	6.3			13.8			1.0		
Cladocera			–							3.2		
Lymnaeidae			–	0.2			23.0	38.4		1.7		
Hirudinea	0.1		–					0.4			3.7	
Planorbidae			–	4.6	0.1		1.9	1.5		8.6	0.7	
Pelecypoda	3.6	12.8	–	14.7	14.4		9.9	15.7		6.8	10.6	
Nematoda			–									
Terrestrial Adults			–			12.8			8.5		3.3	20.6
Total Number	1258	3200	–	475	1577	86	727	1627	116	2715	3092	87
Overlap Index				0.59	0.42		0.21	0.18		0.47	0.23	

* No fish sampled in pond from series I.

Table 7. Percent of identifiable invertebrate composition in Surber (p) and age 0+ chinook salmon stomach (r) samples, and dietary overlap index between samples taken from pond series 1 to 4 channel habitat, Yankee Fork of the Salmon River, 17 July 1989. Total number is the sum of all invertebrates from pooled stomach and Surber samples from each series. Categories within each order are for immatures unless otherwise indicated. Samples size of fish and Surber sample in parentheses.

	POND SERIES							
	1		2		3		4	
TAXON	F(5)	r(20)	P(5)	r(22)	P(5)	r(20)	P(5)	r(15)
Ephemeroptera								
Baetidae	21.5	3.6	0.2	2.4	12.2	2.4	19.1	5.0
Ephemerellidae	2.7		12.1	1.5	1.5	0.5	1.6	
Neptageniidae	2.4		10.4		1.5	0.5	7.9	
Leptophlibiidae	1.0				5.5		8.8	
Siphlonuridae	4.3	1.8	5.7	9.2	1.7	6.8	0.5	2.0
Unknown larvae		3.1		5.3		4.3		5.0
Adult		4.5		5.3		0.5		
Trichoptera								
Lemnephilidae	3.8	2.2	1.5	1.5	4.0	1.0	0.5	
Hydropsychidae			0.2					
Brachycentridae								
Phyacophilidae			0.5		0.6			
Lepidostomatidae			16.8		0.3		1.7	
Hydroptilidae	0.8				0.2			
Psychomyiidae	0.5		0.2					
Unknown larvae				0.5				
Ylecoptera								
Chloroperlidae			0.2		0.9		1.2	
Perlodidae			4.0		0.1			
Diptera								
Chironomidae	46.7	31.7	33.0	62.8	50.0	63.4	48.0	38.0
Tipulidae	2.5	0.5	0.2		0.2		0.5	
Simulidae	0.4				0.2			
Culicidae	0.1		9.8					
Emphimidae					0.8			
Epididae							0.5	
Ceratopoginidae				0.5				
Unknown larvae		0.9		1.9		1.5		
Adult		51.8		8.2		18.5		50.0

Table 7. Continued.

	POND SERIES							
	1		2		3		4	
TAXON	p(5)	r(20)	p(5)	r(22)	p(5)	r(20)	p(5)	r(15)
Coleptera								
Dytiscidae				0.8	-	0.1	-	0.1
Elmidae		0.3	0.5	2.4	0.5	0.2	-	4.8
Hirudinea						0.4	-	0.5
Lymnaeidae						4.5		1.4
Annelida		6.5	-	0.9		3.7		1.6
Pelecypoda		2.5		1.1		8.4	-	0.1
Arachnida		3.3	0.5	0.5	-	-	-	-
Hydrachrina		0.5						
Planorbidae	--					0.5	-	0.3
Total number	224	630	207	655	205	1101	100	926
Overlap Index	0.48		0.72		0.89		0.56	

Chinook Salmon Diet Analvsis

Chinook salmon feeding habits differed between pond and channel habitat (Table 6, 7). For fish collected from pond habitat, their primary prey constituents were chironomid larvae and adults: 36%, 50%, and 50% of all prey items found in fish from PS 2, PS 3, and PS 4, respectively, were chironomids. Terrestrial adults also contributed largely to the diet of pond fish as did siphlonurid and baetid (Ephemeroptera) larvae which made up about 25% of the diet in PS 2 and 3 fish (Table 6). For channel fish, dipteran adults and chironomid (Diptera) larvae contributed 71-88X of their diet in PS 1 to 4 (Table 7). Siphlonurids and baetids (Ephemeroptera) also made a considerable contribution to salmon diet in channel habitat.

Prey selectivity (diet overlap between gut contents and invertebrate availability) by chinook salmon was significant (> 0.60) only in channel habitat (Table 7). Diet overlap values for these fish ranged from 0.48 to 0.89 (mean of 0.66) in PS 1 to 4. Food overlap values were least between pond fish and pond benthos with a mean overlap value of 0.29; overlap between pond fish gut contents and plankton availability averaged 0.41 (Table 6).

We founa that fish in the channels had fuller guts than pond fish; this difference, nowever, was not significant (Figure 12). The mean percent relative dry weight (RDW) of food in the guts of channel fish ranged from 0.78% (PS 2j to 1.11% (PS 3). The RDW values ranged from 0.68% (PS 2) to 0.79% (PS 3) for fish collected in the ponds. In addition to more food in their stomachs, channel fish were also generally in better condition (Figure 12).

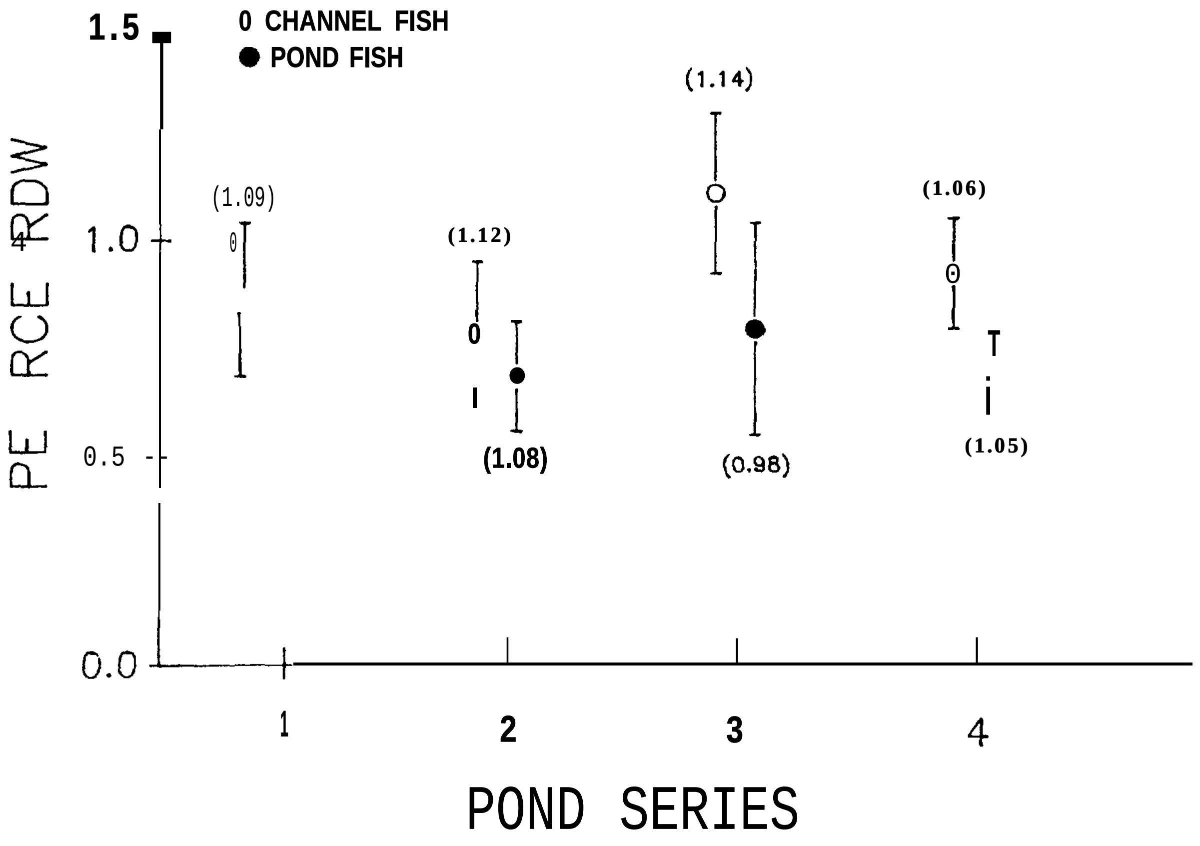

Figure 12. Mean percent relative dry weight (RDW) of chinook salmon gut contents for pond and channel fish collected from 17-21 July in pond series l-4 of the Yankee Fork of the Salmon River, 1989. Error bars represent standard deviation of the mean. Mean condition values are given in parentheses.

DISCUSSION

The pond series represent important rearing areas, especially for naturally-produced and hatchery-outplanted juvenile chinook salmon, in the Yankee Fork system. The total density of chinook salmon in September (range 0.16 to 0.60 fish/m^2) was much greater than in adjacent river strata (0.01 and 0.02 fish/m^2) and compared favorably with the most productive (0.18 fish/n?) river strata, the West Fork. Swales and Levings (1989) also found that chinook salmon used off-channel pond habitat in the Nicola River, British Columbia when it was located near chinook salmon production areas.

Naturally-produced chinook salmon fry utilized PS 4 (our non-hatchery supplemented series) at proportionally greater levels than adjacent main river sites. Pond series 4 is located just downstream of the West Fork, which is a major contributor to chinook salmon production in the Yankee Fork system, and we feel the major source of fish in PS 4. Even though the West Fork contains good quality rearing areas (BNI 1987), fish still move out of the system in June. This may be caused by high flow conditions which could displace the recently emerged fish downstream. In the Wenatchee River, Washington, Hillman et al. (1988) found that high early season chinook salmon densities rapidly decline by July. They suggest that high flows during early summer limit usable rearing habitat resulting in downstream displacement of fish out of the system. In the Yankee Fork, PS 4 provided off-channel refugia to downstream moving fish which otherwise may have left the system.

Production from the ponds has not reached the level originally estimated, However, adult returns to Yankee Fork in recent years have been low resulting in seeding levels much below capacity. As number of spawners increase, fish production from the ponds is expected to increase.

In the Coldwater River, British Columbia, Swales and Levings (1989) estimated that three off-channel ponds (0.1 to 1.0 hectares) produced the equivalent number of coho salmon smolts as would be produced in 5-10 km of river. Despite no chinook salmon smolt production information, we did make a similar estimate based on fall pre-smolt abundance, In September we estimated that 6,087 presmolts were maintained in 34.8 km of the mainstem Yankee Fork (including West Fork and Jordan Creekj. In PS 4 (naturally-produced fish only), we estimated a total of 896 chinook salmon in September. This equates to about 15% of the total pre-smolt production within our study area of the mainstem Yankee Fork. Stated another way, pre-smolts from this 0.32 hectare series supported the equivalent to what would be produced in 5.1 km of river habitat in 1989. Again this emphasizes the importance of these limited areas of off-channel habitat to salmon rearing. Since we do not have overwinter survival and smolt outmigration data this will be an objective of future research. From this information we will be able to more accurately assess the actual production contribution of these off-channel pond areas.

Even though we partially prevented post-stocking downstream movement of fish in PS 3 for three weeks this action appeared to have little effect on abundance reductions of hatchery-outplanted salmon throughout the summer. Bilby and Bisson (1987) found that juvenile coho salmon outplanted in two western Washington streams experienced large abundance reductions soon after release. By the first week of July we estimated an 88% reduction in chinook salmon abundance in PS 3 from the initial stocking level. In PS 2, where June movement of stocked fish was not prevented, we observed an 89% reduction in abundance by the same time. Since we did not monitor fish emigration from the ponds we do not know what percentage mortality contributed to these reductions. It is likely that much of the abundance reduction was due to an initial post-stocking emigration followed by gradual outmigration in subsequent months.

These results are also confounded by the fact that differential movement of fish from the river to these off-channel habitats may have occurred between pond series. In PS 1, by early July, we estimated a 94% reduction in the number of salmon outplanted. This series was not connected to the river at the upstream end which prevented downstream moving fish from entering the upstream end of the series. This is consistent with 1988 data where chinook salmon numbers in PS 3 and PS 4 were reduced by 91% and 96%, respectively by July (Richards et al. 1989). Neither pond series was connected to the river at the upstream end at the time. From the large abundance reduction in PS 1, and comparatively low subsequent densities, we conclude that few salmon moved into this series from the downstream end. Further, by comparing abundance reduction in PS 1 to PS 2 and 3 reductions, it appears that by July, downstream moving chinook probably contributed to about 6% of our abundance estimate in PS 2 and 3, assuming that rates of outmigration were similar among pond series.

This 6% contribution by natural chinook salmon juveniles in PS 2 and 3 is based upon the premise that few if any natural juvenile chinook salmon moved upstream into PS 1. We feel this premise is valid as few fish were observed in the uppermost pond subsequent to post-stocking emigration from this pond. We also saw significantly greater lengths of chinook salmon in this series by the end of the summer leading us to believe there was little movement of natural fish into the system which would have lowered the average mean length. In 1990 with the use of emigrant/immigrant traps we should be able to resolve these movement questions.

We found that the increase in mean chinook salmon length in supplemented ponds differed according to stocking rate but maintained a size advantage over natural fish throughout the sampling period. Lengths were greatest in the series with lowest salmon densities (PS 1 and 2). Pond series 3 maintained the highest density throughout the summer and, correspondingly, fish were significantly smaller than PS 1 and 2 fish in August and September. Naturally-produced fish in PS 4 grew well from July to September but were still smaller than hatchery fish in the other three series by September.

In pond versus channel habitat fish length comparisons varied according to sampling session. In July and August, mean fish lengths were greater in pond habitat compared to channel habitat. By September, however, this trend reversed and fish were larger in channel habitat. From August to September there was considerable movement of salmon from ponds to channels. This fall redistribution likely contributed to the greater fish lengths in channel habitat by September.

Swales and Levings (1489) found that juvenile coho salmon in pond habitat grew faster than fish in adjacent river areas. This faster rate of growth was attributed to warmer pond temperatures. In our study, fish in the ponds did not grow faster than river fish. However, by the end of the summer, mean fish lengths were similar between off-channel pond habitat and river habitat. Accumulated degree days were higher in the river than in the ponds. Contrasting our growth data, fish from PS 1 to 4 were in significantly better condition than fish from adjacent river sites in September. This difference in fish condition may partially be the result of a more favorable temperature regime in the pond series.

From this year's data we feel that the chinook salmon stocking density applied in PS 2 (9.4 fish/m') yielded the most favorable results. Even though

September densities in PS 2 (0.39 fish/m^2) were less than PS 3 (0.60 fish/m'), total abundance reductions were similar by July. Additionally, growth and condition of PS 2 fish were greater than PS 3 fish, an observation which, due to contribution of natural fish, may not be totally attributable to stocking density. These fish should be better equipped to deal with approaching winter conditions and could potentially produce more smolts if greater size and condition of fish results in an overwinter mortality reduction. The greatest growth of chinook salmon was seen in PS 1, however, performance of the stocking density (7.5 fish/m^2) in PS 1 is difficult to compare to PS 2 and 3 since this series was not connected to the river at the upstream end.

The greater mean length and condition of PS 2 fish compared to PS 3 fish was due to a combination of factors. As previously mentioned, lower fish densities were likely a contributing factor. Also, dietary overlap was greatest for fish in the ponds of PS 2. This information suggests that feeding opportunities (i.e., food availability) were greater in PS 2 despite lower total invertebrate densities. Factors such as pond morphometry and emergent vegetation likely contributed to feeding differences,

Chinook salmon habitat selection changed throughout the summer decreasing use of bank habitat, early and late use of channel habitat, use of open habitat in mid-summer. In June, pond bank habitat with cover and channel habitat maintained the greatest proportion of fish. In July and August, the majority of fish preferred open pond habitat. In both months but especially in August, fish preferred cover habitat to habitat with no cover. This may have been a temperature response. We do not have localized temperature data, however, it is plausible that much of the non-vegetated bank habitat had the greatest water temperatures at this time. By September, nearly 60 percent of all pond series fish occupied channel habitat. Chinook salmon primarily used cobble and other cover as overwintering habitat (e.g., Hillman et at. 1987). As temperatures decreased in the ponds, more fish moved to channel habitat where abundant cobble cover was available. Also, if fish did extensively use available cobble cover in ponds, our September abundance may have been underestimated because of limitations on direct observation in this habitat type.

The greater use of cover (primarily vegetation) in all pond habitats by chinook salmon during July and August may have been a response to the combined factors of temperature (discussed above), predation, and food. The ponds are stocked annually with catchable rainbow trout. Personal communication with fishers, although limited, indicated no fish in hatchery rainbow trout stomachs. However, young-of-year chinook may be responding to predator presence by using cover. Further, in the ponds we found the greatest invertebrate (benthic and planktonic) densities in bank and open habitats with vegetative cover. In off-channel ponds of the Coldwater River in British Columbia juvenile coho salmon were most abundant in shoreline habitat with emergent vegetation (Swales and Levings 1989). The Yankee Fork ponds had numerous localized open/shallow areas with vegetation which accounted for extensive fish use of open habitat. This contrasts Swales and Levings findings where fish primarily associated with the bank. Even though we grouped deep and shallow components of open water habitat we rarely observed fish in deeper pond areas where the only effective cover was offered by algae on the pond bottom. These data emphasize the importance of all shallow habitat (bank and open) where vegetative cover is most readily accessible.

The channel habitat in the pond series was important as a rearing area to age 0+ steelhead. Channel use by the younger steelhead continued to increase throughout the summer indicating the habitat is quite desirable for younger age steelhead. Older steelhead use of the pond series declined as the summer progressed; most likely as response to movement down stream in preparation for smoltification the following spring length data on steelhead relate to pre-smolt size and reference,

Even though invertebrate densities were greatest in pond benthos, our feeding data suggest that much of this production is not readily available to chinook salmon as forage. Feeding opportunities appeared to be greatest in channel habitats where dietary overlap was greatest and where chinook salmon had more food in their guts compared to pond fish, From this, one would predict growth to be greater in channel habitats. Our growth data, however, do not support this. This discrepancy is no doubt partially an artifact of fish movement between pond and channel habitat throughout the summer. Also, our dietary analysis was just one snapshot of a dynamic process which probably varied considerably throughout the summer.

Chironotnid larvae and adults were a primary dietary component of chinook salmon fry in Yankee Fork ponds. In two Alaskan lakes where chinook fry were outplanted, benthic invertebrates (primarily chironomids) contributed most to mid-summer tissue production (Hard 1986). Further, Hard found chinook salmon growth to be significantly greater in the lake with the greatest amount of shoal area (80%). Hard concludes that benthic Invertebrates were more readily available to fish in this lake. We found pond fish in PS 2 to have the greatest increase in mean length from July to August. Of the four pond series, PS 2 was the shallowest (BNI 1987), and through casual observation in 1989 this series had the greatest amount of shoal habitat. Even though invertebrate densities were not greatest in PS 2, the actual percentage of invertebrates accessible to fish may have been greater than in other pond series. Clearly, more work is needed to investigate this relationship.

In conclusion, off-channel dredge ponds and associated channels, located in the lower Yankee Fork, were a beneficial summer rearing component both to hatchery-outplanted and naturally-produced chinook salmon. These off-channel habitats are likely to be most important in systems such as the Yankee Fork where mainstem rearing areas are limited. It is likely that water temperature, pond morphometry, and initial stocking densities (or proximity to natural production areas) were all important contributory factors in explaining growth and late summer density differences of juvenile chinook salmon among Yankee Fork pond series. The role of these off-channel habitats to the winter ecology and direct smolt production of chinook salmon is unknown. This will be an additional goal of future investigation.

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Appendix A. Summary of Yankee Fork pond construction activity.

The construction phase of the Yankee Fork Fisheries Enhancement Project was completed in 1985. The project started in 1986 with the initiation of a feasibility study. The feasibility study was finished in 1987 in January and the Environmental Assessment was then issued the following July, Due to the lateness in the season, construction activity begun in September, lasted only about a month. Almost all construction was subsequently finished during the 1988 field season. All that remained for the 1989 season was remedial work and fine-tuning of prior work. A brief summary of yearly construction activity is as follows:

1987 - Check structures and channels between ponds, including outlets, constructed in Pond Series (PS) 3 and 4.

1988 - Intakes to main river built for PS 3 and 4. Additional check structure built in PS 4. All work completed in PS 1 and 2. Selected areas riprapped. Revegetation work in all pond series.

1989 - Adjustment of previous work. Correction of some problems. Revegetation.

A total of 16 ponds in four pond series representing approximately 3.9 acres of water were connected over the construction phase. Fifteen check structures were built to provide flow control through the system of ponds.

Almost 27,000 cubic yards were handled during construction. This total included 25,000 cubic yards of excavation and backfill. Rock work (riprap and boulder placement) accounted for almost 2,000 cubic yards. In addition, 170 cubic yards of concrete was poured.

Every effort was made to construct channels to imitate natural streams in both appearance and flow characteristics. Large boulders were manually and strategically placed in connecting channels to dissipate energy and reduce velocity thereby improving rearing habitat for juvenile fish.

Revegetation efforts covered approximately 11 acres throughout the pond series. In addition, over 4100 willows were planted around the four pond series. Where possible, trees and shrubs that required removal were transplanted to augment existing riparian revegetation.

As much as possible, impacts on the environment from construction activities were kept to a minimum. Various techniques were used to minimize sediment input. Water quality, especially heavy metal input, was monitored before, during, and after construction. No problems were detected. Turbidity was checked daily. Due to the permeability of the valley floor (a result of the dredge mining), there was concern that Yankee Fork flows might be partially or completely diverted through the dredge material. Consequently, water level monitoring of the river was conducted. No significant changes in the water level occurred during the construction phase.

Total cost for the project came in under budget. Costs for 1987, 1988, and 1989 were $141,000, $402,000, and $96,000, respectively. This total of $639,000 was about $130,000 less than the original cost estimate of $770,000.

Appendix B. Two-way analysis of variance for fish densities by habitat type and cover, pond series 1 to 4 sample combined, Yankee Fork of the Salmon River, 1989. An asterisk denotes significance at the 0.05 alpha probability.

SESSION	SOURCE	F-RATIO	N	PROBABILITY
	Cover	2.31		0.132
1	Habitat Type	1.86	93	0.161
(June)	HT * Cover	2.15		0.122
	Cover	0.13		0.911
2	HT Habitat * Cover Type	0.27 0.77	125	0.465 0.766
(July)				
3	Cover	0.02		0.879
(Aug)	Habitat HT * Cover Type	0.54 1.23	90	0.299 0.586
	Cover	3.14		0.080
4	Habitat Type	0.76	86	0.470
(Sept)	HT * Cover	1.58		0.212

Appendix C. Analysis of variance comparing total fish lengths (mm) among pond series by session, June through September, Yankee Fork of the Salmon Kiver, 1989. Pond and channel fish lengths are combined for each pond series. An asterisk denotes significant at the 0.05 alpha probability.

SESSION	SOURCE	F-RATIO	DF	PROBABILITY
June [1]	Among ponds	3.32	104,2	0.06
July	Among ponds	62.09	522,3	0.00 *
August	Among ponds	43.66	339,3	0.00 *
September	Among ponds	99.48	384,3	0.00 *

[1] No chinook salmon in pond series 4.

Appendix D. Mean and standard deviation of invertebrate densities (no./.1m³) for plankton samples taken from different pond habitat in pond series l-4, Yankee Fork of the Salmon River, July 1989. Sample size for each habitat type is given in parentheses.

	HABITAT TYPE (POND SERIES 1) - PLANKTON							
	Open Cover (2)		Open No Cover (3)		Bank Cover (6)		Bank No Cover (6)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Ephemeroptera								
Ameletus spp.					0.85	1.70		
Baetis spp.					6.94	8.37		
Paraleptophlebia spp.					1.13	2.77		
Siphlonurus spp.					1.55	2.76		
Tricoptera								
Brachycentrus spp.					0.14	0.34		
Ecclisomyia spp.	1.70	2.40			10.05	13.47		
Hydroptina spp.					0.14	0.34		
Ironoquia spp.					0.14	0.34		
Theliopsyche spp.					0.14	0.34		
Diptera								
Chironomidae	32.72	36.66	0.56	0.98	58.37	86.02	14.60	32.43
Ceratopogonidae							0.14	0.34
Emphimidae	0.85	1.20			1.70	2.63		
Empididae					0.14	0.34	0.42	1.04
Coltoptera								
Brychius spp.							0.14	0.34
Hemiptera								
Corixidae					22.38	38.78	2.97	4.42
Hesperocorixa spp.							0.42	1.04
Trepobates spp.					0.28	0.69		
Hymenoptera					0.70	1.73		
Arachnida	26.77	37.86			13.03	26.39		
Annelida	0.85	1.20			2.65	5.44	3.11	6.12
Hydracarina	6.37	0.60	0.8501	0.00	0.42	1.04	3.82	9.37
Copepoda	3.82	1.80			0.28	0.69		
Pelecypoda					3.40	5.68	2.97	4.42
Hirudinea							0.14	0.34

Appendix D. Continued.

	HABITAT TYPE (POND SERIES 2) - PLANKTON							
	Open Cover (3)		Open No Cover (3)		Bank Cover (6)		Bank No Cover (6)	
TAXON	x	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Ephemeroptera								
Callibaetis spp.					3.96	9.71		
Paraleptophlebia spp.	0.28	0.49			0.42	1.04	0.28	0.43
Serratella spp.	0.28	0.49						
Siphlonurus spp.	0.28	0.49			5.24	7.33	0.70	0.99
Tricoptera								
Ecclosomyia spp.	3.68	3.53	0.28	0.49	1.55	1.97	0.14	0.34
Diptera								
Chironomidae	17.56	14.85	1.41	1.25	5.80	5.90	1.98	3.47
Ceratopogonidae	6.51	11.28	0.28	0.45	4.25	6.58	0.14	0.34
Culicidae			0.28	0.49	0.85	2.08		
Ephydridae					0.99	2.43		
Tipulidae					0.70	1.36		
liemiptera								
Hesperocorixa spp.					0.85	2.08	2.69	5.11
Hymenoptera								
Trichogrammatidae	0.28	0.49	0.85	0.85				
Dacnusa spp.					0.95	1.64	0.14	0.34
Coleoptera								
Agabus spp.					0.28	0.69		
Brychius spp.							0.28	0.69
Hydroporus spp.					0.14	0.34		
Hygrotus spp.					0.28	0.69	0.14	0.34
Hyperodes spp.					0.14	0.34		
Oreodytes spp.							0.14	0.34
Odonata								
Aeshna spp.							0.14	0.34
Pelecypoda					9.91	22.27		
Copepoda					4.25	10.41		
Lymnaeidae					0.14	0.34		
Planozgidae					3.11	5.28		
Arachnida			0.56	0.98	0.56	0.69	0.14	0.34
Annelida	0.85	1.47						

Appendix D. Continued.

	HABITAT TYPE (POND SERIES 3) - PLANKTON							
	Open Cover (3)		Open No Cover (3)		Bank Cover (6)		Bank No Cover (6)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	x	sd	$\bar{x}$	sd
Ephemeroptera								
Baetis spp.					1.70	4.16	0.85	1.31
Callibaetis spp.					1.27	2.38	0.85	1.42
Paraleptophlebia spp.					0.85	2.08		
Siphlonurus spp.					0.70	1.36	0.28	0.69
Coleoptera								
Brychius spp.					0.14	0.34		
Haliphus spp.					0.28	0.69	0.28	0.44
Heterlimnius spp.					0.14	0.34		
Hydroporous spp.	0.28	0.49			0.14	0.34		
Oreodytes spp.					0.85	1.70	0.99	1.36
Tricoptera								
Ecclisomyia spp.	0.28	0.49			1.70	2.94	0.14	0.34
Rhyacophina spp.							0.14	0.34
Megaloptera								
Sialis spy.					0.28	0.69		
Hemiptera								
Corixidae					0.85	1.31		
Hesperocorixa spp.					4.56	7.52		
Hymenoptera								
Trichogrammatidae	0.28	0.49						
Diptera								
Ceratopogonidae	27.76	44.46			7.50	18.39	0.42	1.04
Chironomidae			0.56	0.58	4.95	6.23	3.54	5.97
Culicidae	0.28	0.49					0.14	0.34
Emphimidae			0.28	0.49				
Empididae	0.28	0.49						
Ephydridae					0.42	0.46		
Tipulidae	0.56	0.49			0.56	1.38	0.14	0.34
Aunelida	1.13	1.96	0.28	0.49	0.14	0.34	0.56	1.38
Arachnida	1.41	2.45	0.85	1.47	1.27	1.67	0.42	1.04
Copepoda	4.81	8.34	7.36	11.31	7.65	8.50	0.42	1.04
tiydracarina			0.28	0.49				
Lymnaeidae	1.98	3.43			10.62	13.37	12.81	15.86
Pelecypoda	17.28	29.20			0.70	1.36	0.85	1.70
Planorbidae					0.14	0.34	1.84	2.42

Appendix D. Completed.

	HABITAT TYPE (POND SERIES 4) - PLANKTON							
	Open Cover (3)		Open No Cover (3)		Bank Cover (6)		Bank No Cover (6)	
TAXON	x	sd	x̄	sd	x	sd	x̄	sd
Ephemeroptera								
Ameletus spp.	0.28	0.45			0.14	0.34	0.85	1.70
Baetis spp.	0.28	0.49			2.55	5.84		
Callibaetis spp.	16.15	27.97			19.40	23.05	1.13	2.77
Leptophlebia spp.					0.70	1.73	1.64	2.26
Paraleptophlebia spp.	0.28	0.49			1.27	3.12	0.99	2.43
Siphlonurus spp.	0.28	0.49			198.63	299.63	0.42	0.71
Tricoptera								
Ecclisomyia spp.	5.38	8.50	0.28	0.49	22.24	15.04		
Micrasema spp.					0.14	0.34		
Oligoplectrum spp.					0.14	0.34		
Theliopsyche spp.					1.13	2.05		
Hemiptera								
Corixidae					5.54	7.30	2.40	5.90
Hesperocorixa spp.					9.63	19.72	4.10	8.50
Hymenoptera								
Trichogrammatidae					0.28	0.69	0.14	0.34
Diptera								
Chironomidae	41.66	72.16	0.56	0.98	36.70	48.24	2.83	4.94
Ceratopogonidae	12.18	10.62	0.28	0.49	11.75	28.38	1.55	3.81
Culicidae					0.14	0.34		
Ephydridae	2.83	3.53			2.40	5.50	0.14	0.34
Syrphidae					0.14	0.34	0.14	0.34
Plecoptera								
Chloroperlidae					0.14	0.34		
Coleoptera								
Agabus spp.	0.85	1.47			0.70	1.13		
Cleptelmis spp.	0.28	0.49					0.28	0.69
Heterlimnius spp.					0.56	1.38		
Haliphus spp.	2.55	4.41			0.99	2.42	1.68	2.05
Hydroporous spp.	2.83	4.90			0.70	1.73	0.14	0.34
Hyperodes spp.								
Oreodytes spp.	1.70	2.94			0.99	1.73	0.28	0.44
Arachnida	67.15	115.58	2.26	3.21	33.86	48.35	1.13	1.80
Annelida					0.70	1.36		
Copepoda					3.40	6.71	0.28	0.69
Cladocera					12.04	23.80	0.14	0.34
Mydracarina	0.28	0.49			2.55	5.83	0.70	1.73
Lymnaeidae	4.81	8.34						
Prlecypoda	0.28	0.49	0.28	0.49	25.78	40.09		
Planorbidae	27.77	48.10			19.14	46.47		

ppendix E. Mean and standard deviation of invertebrate densities (no./.1m³) for Ponar dredge samples taken from different pond habitat in pond series l-4, Yankee Fork of the Salmon River, July 1989. Sample size for each habitat type is given in parentheses

	HABITAT TYPE (POND SERIES 1) - PONAR							
	Open Cover (6)		Open No Cover (6)		Eank Cover (3)		Bank No Cover (3)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
nnelida								
Oligochaeta	13941 .0	19282.7	737.0	804.1	1476.8	1275.4	1112.5	1782.4
Hi rudina					-	-	13.9	24.1
rachnida								
Hydracarina	62.2	133.9	6.95	17.03	41.7	72.3	-	-
oloptera								
Donacia spp.								
Agabus spp.								
Hydroporus spp.					-	-	-	-
Hygrotus spp.					-	-	-	-
Oreodytes spp.	6.95	17.03	6.95	17.03	13.9	24.1	41.7	72.3
Optioservus spp.								
Stenelmis spp.					-	-	-	-
Brychius spp.	13.91	34.06			41.7	41.7	-	-
haliplus spp.					-	-	-	-
iptera								
Ceratopogonidae					-	-		
Chironomidae	757.9	1135.3	584.1	516.4	709.2	451.2	667.;	423.4
Empidi dae					-	-		
Ta banus spp.					-	-		
Hybomitra spp.			6.95	17.03	-	-	13.9	24.1
Dicranota spp.					-	-		
Tipula spp.	6.95	17.03			55.6	63.8	111.3	192.7
phemeroptera								
Baetis spp.	6.95	17.03	6.95	17.03	27.8	24.1	111.3	192.7
Callibaetis spp.								
Paraleptophlebia spp	6.95	17.03			13.9	24.1	27.8	48.2
Ameletus spp.					13.9	24.1	13.9	24.1
Siphlonurus spp.					13.9	24.1	-	-
emiptera								
Hesperocorixa spp.	6.95	17.03			13.9	24.1	-	-
egaloptera								
Sialis spp.					-	-	-	-
ricoptera								
Hydroptila spp.			20.9	51.1	-	-	-	-
Lepidostoma spp.			6.95	17.03	-	-	-	-
Ecclisomyia spp.	368.5	293.1	41.7	83.4	056.9	1577.8	-	-
Khycophila spp.					-	-	-	-
ol lusca								
Pl anorbioae	6.95	1'7.03						
Sphaeriidae	1328.1	1609.6	1077.8	919.3	742.0	412.2	125.2	110.4

Appendix E. Continued,

	HABITAT TYPE (POND SERIES 2) - PONAR							
	Open Cover (6)		Open No Cover (6)		Bank Cover (3)		Bank No Cover (3)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Colodtera								
Donacia spp.	6.95	17.03	-			-		
Hydroporus spp.			-			-	13.9	24.
Diptera								
Ceratopogonidae	521.5	1277.4	6.95	17.03			41.7	72.
Chironomidae	2586.6	4668.3	869.2	767.6	1154.2	376.2	389.4	674.
Hybomitra spp.			6.95	17.03				
Dicranota spp.	-	-					13.9	24.
Tipul a spp.	-	-					13.9	24.
Ephemeroptera								
Callibaetis spp.	13.9	21.5	-		27.8	24.1		
Siphonurus spp.	6.95	17.03	-				13.9	24.
Hemiptera								
Hesperocorixa spp.	-	-	-			-	13.9	24.
Megacoptera								
Sialis spp.	6.95	17.03	6.95	17.03	69.5	120.4	13.9	24.
Odonata								
Aeshna spp.	-	-	6.95	17.03	13.9	24.1	-	
Tricoptera								
Ecclisomyia spp.	493.7	993.0	6.95	17.03	13.9	24.1	27.8	24.
Annelida								
Ol igochaeta	3810.3	7215.7	160.0	133.0	166.9	253.8	194.7	1.73.
Arachnida								
Hydracarina spp.	111.30	272.5	-		27.8	24.1	13.9	24.
Mol lusca								
Planorbidae	-	-	-		13.9	24.1		
Sphaeriidae	924.8	1151.8	34.8	41.0000	556.2	927.6	681.4	619

Appendix E. Continued.

	HABITAT TYPE (POND SERIES 3) - PONAR							
	Open Cover (6)		Open No Cover (6)		Bank Cover (3)		Bank No Cover (3)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	x	sd	$\bar{x}$	sd
Coloptera								
Oreodytes spp.	6.95	17.03						
Optioservus spp.	6.95	17.03						
Haliplus spp.	13.9	21.5	6.95	17.03			55.6	48.2
Diptera								
Chironomidae	375.7	414.7	271.4	240.1	557.2	965.0	264.6	422.8
Empididae			6.95	17.03				
Tabanus spp.			6.95	17.03				
Tipulidae spp.							13.9	24.1
Ephemeroptera								
Baetis spp.	6.95	17.03		-	69.6	120.6	41.8	72.4
Callibaetis spp.				-				
Paraleptophlebia spp				-	404.0	700.0	264.7	251.9
Siphlonurus spp.				-	640.7	1073.9		
Megaloptera								
Sialis spy.	20.9	34.9	13.9	21.5	55.7	96.5		
Tricoptera								
Hydroptila spp.			125.4	307.1				
Lepidostoma spp.	6.95	17.05			139.3	206.2	27.8	48.2
Ecclisomyia spp.	27.8	50.5	20.9	51.1				
Rhycophila spp.					13.9	24.1	13.9	24.1
Annelida								
Hirudinea spp.	27.8	68.1					27.8	24.1
Oligochaeta	877.2	1038.6	1509.8	761.6	270.7	245.2	445.7	700.9
Arachnida								
Hydracarina spp.	6.95	17.01	6.95	17.03	55.7	96.5		
Mollusca								
Lymnaeidae	2352.1	2333.6	897.4	646.9	1058.6	1546.4	1128.3	875.6
Planorbidae	34.8	31.4	34.8	66.9	195.0	302.3	13.9	24.1
Sphaeriidae	598.9	695.1	730.6	799.8	766.1	1011.9	139.3	127.7

Appendix E. Completed.

	HABITAT TYPE (POND SERIES 4) - PONAR							
	Open Cover (6)		Open No Cover (6)		Bank Cover (3)		Bank No Cove (3)	
TAXON	$\bar{x}$	sd	x	sd	$\bar{x}$	sd	$\bar{x}$	s
Coloptera								
Agabus spp.	6.95	17.03						
Hygrotus spp.	20.Y	34.9	13.Y	34.1	13.9	24.1		
Oreodytes spp.		-	34.8	66.9	139.1	169.0	41.7	72
Stenelmis spp.		-					13.9	24
brychius spp.		-						
Haliplus spp.	-	-			13.9	24.1	13.9	24
Diptera								
Ceratopogonidae			27.8	50.5	83.4	144.5		
Chironomidae	3456.0	3306.0	1474.0	1344.0	10527.0	17154.0	320.0	337
Ephemeroptera								
Baetis spp.			6.95	17.03				
Callibaetis spp.	13.9	21.5			139.1	241.0	41.7	72
Paraleptophlebia spp					7537.0	12983.0	306.0	293
Siphlonurus spp.	41.7	102.2			264.2	251.4	125.2	
Hemiptera								
Hesperocorixa spp.	55.6	117.0	6.95	17.03	-	-	-	
Negaloptera								
Sialis spp.	13.9	34.1	48.7	100.2	-	-	-	
Tricoptera								
Ecclisonryia spp.	34.8	66.9			27.8	24.1		
Rycophila spp.			13.Y	34.1			13.9	24
Annelida								
Hirudinea spp.	472.8	642.0	243.4	498.0	27.8	48.2	111.3	19[illegible]
Oligochaeta	549.0	863.0	1954.0	2712.0	125.2	216.8	194.7	261
Arachnida								
Hyciracarina spp.	55.6	117.0	6.95	17.03	55.6	96.3	-	
Lymnaeidae	27.8	68.1			139.1	241.0	-	
Mollusca								
Planorbidae	13.9	34.1	6.95	17.03	236.4	410.0		
Sphaeriidae	960.0	898.0	653.6	1046.0	139.1	241.0	1210.0	204

Appendix F. Mean and standard deviation of invertebrate densities (no./.1m^3) for Surber samples taken from channel habitat in pond series l-4, and adjacent mainstem sites, Yankee Fork of the Salmon River, July 1989. Sample size for each series is given in parentheses.

	SERBER SAMPLES									
	Pond Series 1 (4)		Pond Series 2 (5)		Pond Series 3 (6)		Pond Series 4 (5)		Mains tern River	
TAXON	x	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Ephemeroptera										
Ameletus spp.	18.90	37.80	4.32	9.66	64.80	75.60	10.80	13.22	45.36	47.93
Baetis spy.	367.20	459.22			241.20	270.61	382.32	211.02	542.16	386.42
Callibaetis spp.			2.16	4.83						
Cinygmula spp.			43.20	46.45	30.60	74.95	154.68	352.58	97.20	55.60
Drunella spp.	43.20	86.40	10.80	13.22	1.80	4.40			41.04	42.10
Epeorus spp.	40.50	81.0	47.52	55.38						
Leptophlebia spp.	16.20	32.40	-						-	
Paraleptophlebia spp.				-	108.0	111.20	174.96	158.61		
Rithrogena spp.			56.16	72.20					79.92	135.66
Serratella spp.	2.70	5.40	159.84	113.88	27.0	31.85	32.40	72.44	235.44	215.51
Siphlonurus spp.	54.0	49.10	75.60	75.21	1.80	4.40			49.68	44.92
Tricoptera										
Hydropsychidae	-	-	2.16	4.83			-	-	-	
Limnephilidae	-	-	10.80	10.80		-	-	-	-	
Leyidostomatidae	-	-	229.0	512.0			-	-	-	
Rhyacophi lidae	-	-	6.48	14.50			-	-		
Brachycentrus spp,	-	-					-		8.64	19.32
Ceratopsyche spp.							-	-	4.32	9.66
Ecclisomyia spp.	62.10	103.73	10.80	10.80	79.20	120.20	10.80	10.80		
Hydroptina spp.	13.50	27.00			3.60	8.81	-	-	2.16	4.83
Ironoquia spp.	2.70	5.40					-	-		
Lepidostoma spp.			8.64	19.32	5.40	13.22	10.80	10.80		
Parasyche spp.							-	-	2.16	4.83
Psychomia spp.	8.10	16.20	2.16	4.83			-	-		
Rhyacophila spp.	-	-	-	-	12.60	15.90	-	-	8.64	4.83
Theliopsyche spp.	-	-	-	-			23.76	24.62	572.40	397.77

Appendix F. Continued.

	SERBER SAMPLES									
	Pond Series 1 (4)		Pond Series 2 (5)		Pond Series 3 (6)		Pond Series 4 (5)		Mainstem River	
TAXON	x	sd	x̄	sd	x̄	sd	x̄	sd	x̄	sd
Coltoptera										
Agabus spp.	-			-			2.16	4.83		
Brychius spp.							6.64	14.0%		
Cleptelmis spp.			-		1.80	4.40			8.64	9.03
Haliplus spp.					41.40	76.20				-
Heterlimnius spp.			6.48	9.66			12.96	28.97	4.32	5.91
Hydroporus spp.			10.80	13.22	1.80	4.40				
Narpus spp.									4.32	9.65
Optioservus syp.	5.40	10.80	28.0%	56.94	1.80	4.40	82.0%	118.94	15.12	14.48
Oreodytes spp.									4.32	9.65
Plecoptera										
Chloroperl idae	-		2.16	4.83	18.00	20.10	23.76	53.13	144.72	96.77
Kathroperla spp.		-			1.80	4.40				
Isoperla spp.						-			4.32	5.91
Skwala spp.			2.16	4.83						
Setvena spp .			54.0	35.82					-	
Hemiptera										
Corixidae			-	-	-	-	2.16	4.83	-	-
Hesperocorixa spp.	5.40	10.80	-	-	-	-				-
Megaloptera										
Sialis spp.	-			-	21.60	39.23	4.32	5.91	-	-
Arachnida	56.70	76.55	8.64	19.32	-				38.88	57.95
Annelida	110.70	153.84	12.96	14.08	73.80	106.35	32.40	35.82	71.12	100.23
Hydracarina	8.10	16.20	-	-	-				-	
Hymenoptera									2.16	4.83
Hirudinea		-			7.20	17.63	10.80	24.15	2.16	4.83
Lymnaeidae				-	90.00	173.02	28.0%	45.56	-	-
Planorbidae					9.00	22.04	6.4%	9.65	-	-
Pelecypoda	43.20	59.15	15.12	33.80	165.60	178.60	2.16	4.83	-	-

Appendix F. Completed.

	SERBER SAMPLES									
	Pond Series 1 (4)		Pond Series 2 (5)		Pond Series 3 (6)		Pond Series 4 (5)		Mainstem River	
TAXON	x	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Diptera										
Ceratopogonidae	-		-				-		8.64	19.31
Chironomidae	804.60	710.75	466.56	654.06	990.00	727.81	959.04	626.65	824.12	866.21
Culicidae	16.20	32.40	138.24	131.25	-					
Emphimidae	-				16.20	21.32				
Empididae	-		-				10.80	10.80	-	
Ephydridae	-					-	-		9.32	9.65
Simuliidae	2.40	5.40			3.60	5.57			9.32	9.65
Antocha spp.	-		-						6.48	9.65
Atherix spp.									2.96	4.71
Dicranota spp.	2.70	5.40				-				
Hesperoconopa spp.	8.10	16.20	-				-			-
Hybomitra spp.	-	-	-							
Hexatoma spp.					3.60	8.81			6.4%	14.4%
Pericoma spp.	2.70	5.40	-							
Tipula spp.	32.40	64.80	2.16	4.83	10.80	24.15	-		6.48	9.65

ABSTRACT

East Fork

The East Fork of the Salmon River drainage is an important spawning and rearing area for spring chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss). Agricultural, grazing, and mining practices in the drainage have degraded available habitat. In the spring of 1988, an interagency task force selected a preferred alternative for the enhancement of anadromous fisheries habitat in the East Fork drainage. The proposed measures include work on Big Boulder and herd creeks. In Big Boulder Creek plans are to remove an abandoned hydroelectric dam and debris jam, and stabilize a severely eroding channel. In Herd Creek, fencing, revegetation, and bank stabilization are planned. A final environmental assessment is being developed with proposed work scheduled to commence by late summer 1990.

Extensive physical and biological inventories were conducted on Herd and Big Boulder creeks and mainstem East Fork reaches in 1988. In 1989, we continued to monitor sediment levels in lower Herd Creek and conducted a fisheries evaluation tbroughout the East Fork. Sediment levels from core samples in lower Herd Creek did not differ significantly between 1988 and 1989 at 15.5 and 19.5%, respectively. In June, chinook salmon densities (fish/100m^2pool) were greatest in Herd Creek at 129 fish and upper East Fork at 179 fish. By September, chinook salmon densities had declined but were still greatest in Herd Creek and upper East Fork, 79 and 18 fish/100m^2pool, respectively. Mean total fish densities were lowest in Big Boulder Creek for both sampling sessions. In 1989, the 14 chinook salmon redds we counted in Herd Creek were far less than the 58 redds observed in 1988.

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INTRODUCTION

The East Fork of the Salmon River, a major tributary of the Salmon River, is a spawning and rearing stream for anadromous salmonids. Wild spring and summer chinook (Oncorhynchus tshawytscha) redd counts have declined from over 800 in the early 1960's to below 100 in the 1980's (Schwartzberg and Rogers 1986). Steelhead trout (O. mykisa) also use the East Fork system for spawning and rearing. Reductions in spawning escapements can largely be attributed to downstream (Snake and Columbia rivers) hydroelectric facility passage problems, however, this problem has been further exacerbated by habitat degradation throughout the East Fork drainage.

Through Bonneville Power Administration (BPA) funding, baseline nabitat and fish inventories were conducted by the Shoshone-Bannock Tribes in Herd Creek during 1485 (Konopacky et al. 1986), and in the East Fork of the Salmon River, including Big Boulder Creek and Herd Creek (Richards and Cernera 1987) in 1986. Physical and biological evaluations of the drainage continued in 1987 and 1988 (Richards and Cernera 1988; Richards et al. 1989). These inventories indentified several habitat problems associated with the drainage.

In August 1987, the Tribes released a request for proposals (RFP) to conduct a feasibility study within the drainage and formulate a renediation plan. During the summer of 1987, EA Engineering, Science, and 'Technology, Inc. of Lafayette, CA (EA) was awarded the contract and began a feasibility study to develop alternatives for anadromous fisheries enhancement in the East Fork drainage.

From late 1987 to the end of 1989, the project evolved to the draft environmental assessment stage. In December 1987, an interagency task force (consisting of representatives of the Tribes, BPA, US Forest Service, Idaho Fish and Game, and Bureau of Land Management) meeting was held to review progress on the project and to make initial decisions on the primary focus of alternative development. The Tribes and EA continued to work on the study throughout the winter.

In the spring of 1988, another interagency task force meeting was held and a preferred alternative was selected. This alternative focuses on stabilizing a large cut bank on Big Boulder Creek and the removal of a small hydroelectric dam and a minor debris jam in the lower reaches of the same stream. On Herd Creek, sedimentation problems associated with grazing practices will be addressed. Treatment will include localized fencing and revegetation of disturbed riparian areas.

According to the feasibility study (EA 1988) large increases in juvenile production would result from implementation of these actions. Removal of the dam in Big Boulder Creek would open up 2.0 miles of spawning habitat and 4.8 miles of rearing habitat to spring chinook and summer steelhead. In conjunction with stabilization of the cut bank, removal of the dam would result in an increased production of 32,832 chinook smolts and 4,818 steelhead smolts. These figures are based on new spawning habitat available at full seeding levels. In Herd Creek a conservative estimate of a 30% reduction in embeddedness, due to the proposed remedial activities, would result in a three-fold increase in chinook smolt production to 70,000 fish and more than a five-fold increase in steelhead to 27,500 smolts in the affected area, A 50% reduction in embeddedness would increase production in the affected area by about 960% for both chinook and steelhead.

The physical and biotic condition of Road Creek was also assessed in 1988. Spawning and rearing habitat was in poor condition and no anadromous fish use was documented (Richards et al. 1989). Due to extensive non-point source contributions to the sediment problem in upstream sections, the Tribes have not identified a specific treatment remedy. However, through cooperation with the Bureau of Land Management, the Tribes will work towards improving fisheries habitat via improved land management practices.

The environmental assessment process is continuing. A draft environmental assessment was completed December 1988 and distributed for public review and comment. A finalized feasibility report and environmental assessment will be completed by summer of 1990.

Since an extensive base of physical habitat data was obtained in 1988, and proposed work has not proceeded, our 1989 physical work was minimal. We uid, however, continue sediment monitoring in lower Herd Creek. Like previous years, we continued an inventory of fish communities in the East Fork, Herd Creek, and Big Boulder Creek.

STUDY AREA

The East Fork of the Salmon River is located in Custer County, Idaho (Figure 1). Herd Creek and Big Boulder Creek are two major tributaries to the East Fork Salmon River. Other important tributaries to the East Fork include Little Boulder, Wickiup, Germania, Bowery, Road, and West Pass creeks. The East Fork of the Salmon River drainage is a low to medium gradient system which flows through moderately wide valleys of lodgepole pine (Pinus contorta) and Douglas fir (Pseudotsuga menziesii) forests, improved pasture ranchlands,

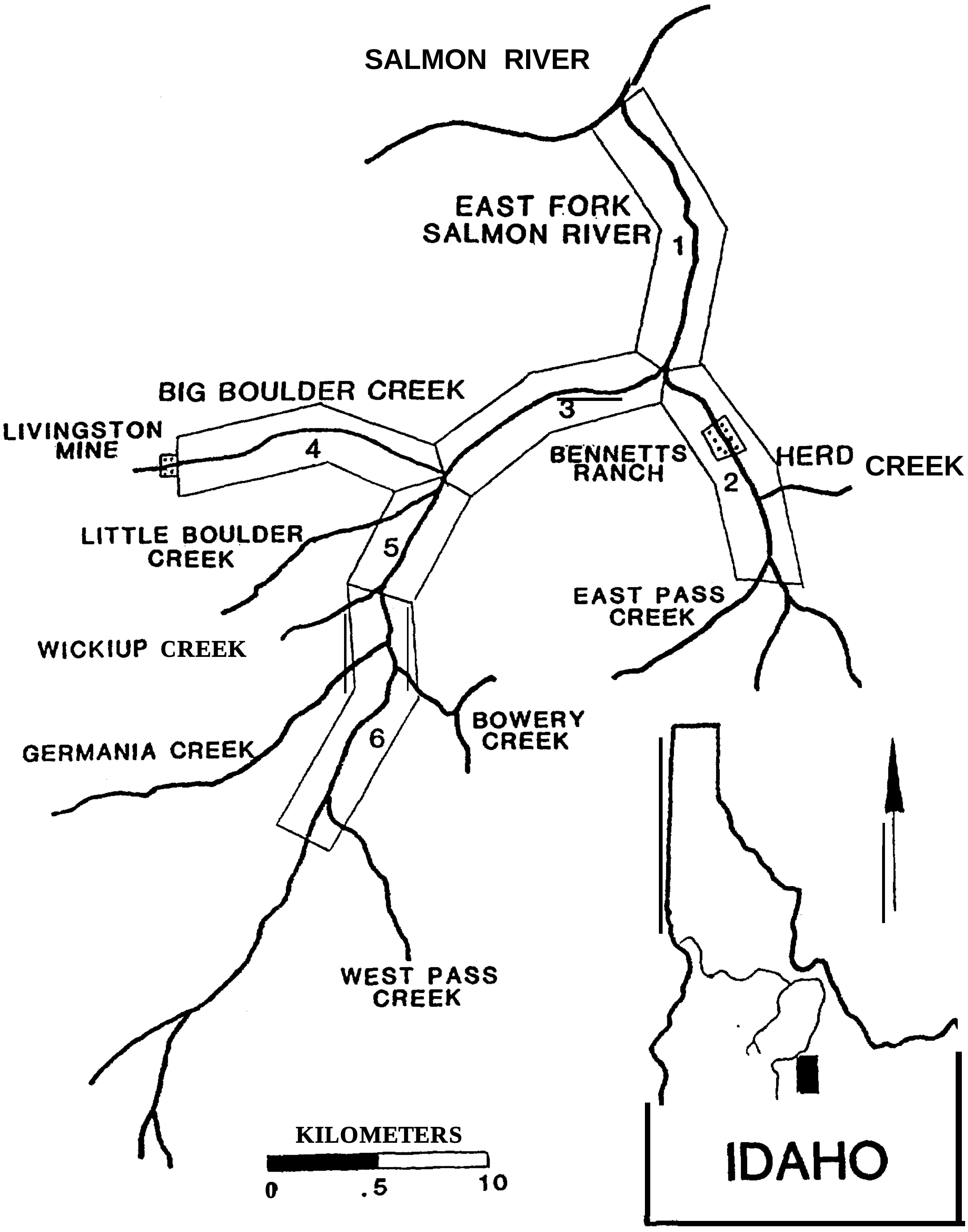

Figure 1. East Fork of the Salmon River, Idaho, study area and strata location.

sagebrush/grass valleys, and narrow canyons. Most of the system is roaded and lies in an area of Challis Volcanics which is characterized by highly erosive sandy and clay-loam soils. Roads parallel almost all of the East Fork, Big Boulder Creek, Herd Creek, and Road Creek. Adjacent lands are managed by the United States Forest Service (Challis National Forest), Bureau of Land Management (Salmon District) , and private landowners.

Biological monitoring was conducted in the lower 46 km of the mainstem East Fork; in Big boulder Creek from its confluence with the East Fork upstream to the Livingston Mine (7 km); and in Herd Creek from its East Fork confluence upstream 15.5 km to the East Pass Creek confluence. The only physical monitoring done was core sampling in the lower portion of Herd Creek.

METHODS

Fish densities were assessed during the last week of June and the third week of September. Observations were conducted by divers equipped with snorkel and mask following techniques outlined in Platts et al. (1983). All observations were conducted between 1100-1500 hours. Observations were conducted in pools at the same site and strata locations as in previous years (Richards and Cernera 1987). As in 1988, stratum 5 was not sampled because of landowner/access difficulties. Abundance of age 0+ chinook salmon was calculated for June and September using mean and variance values obtained from snorkel surveys following techniques outlined in Scheaffer et al. (1979). Analysis of variance (ANOVA) was used to compare fish density means among strata and between sessions. When a main effect term had a significant interaction, Tukey's multiple range test was used to discern where the difference occurred. Significance was determined using an alpha probability of 0.05. Normality was tested for in the dependent variable; a log transformation was applied, if necessary, prior to using parametric tests (Helwig and Council 1974).

Fifty age 0+ chinook salmon were collected from available habitats within each stratum by electrofishing during both sessions. Fish were measured for total length (mm) and weight (grams). Prior to measurement, fish were anesthetized with MS-222. After measurement, fish were held in fresh water until revived, then released back into a calm water area of the stream.

A ground survey of redd abundance was conducted on herd Creek on 15 September, 1989. Our survey began at the confluence of kest Pass Creek with Herd Creek and continued downstream to the confluence with the East Fork of the Salmon River. Due to the large size of the mainstem East Fork, we did not conduct a ground survey of redds.

McNeil core samples (2/riffle) were taken in the lower three sites of Herd Creek - one site around Bennetts' ranch and two sites below the ranch. Core samples were analyzed following procedures outlined in Richards and Cernera (1987). Similarity of substrate size class distributions was compared between 1988 and 1984 using chi-square analysis. The percent silt (particles less than 0.65 mm) in cores was compared between years (1988 and 1989) using a two-sample t-test on arc sin transformed values. An alpha probability of 0.05 was used to detect significance.

RESULTS AND DISCUSSION

Physical Evaluation

September 1989 flows along the East Fork proper ranged from 1.00 m^3/s in stratum 6 to 2.65 m^3/s in stratum 1. Flows in two primary tributaries of interest, Herd Creek and big Boulder Creek, were 0.60 m^3/s and 0.50 m^3/s, respectively. These late season flows are considerably greater than those measured in 1988, a year influenced by two previous drought years (Table 1). Flows in 1989, however, were similar to those recorded in 1987.

Particle size distribution from core samples taken in lower Herd Creek, below Bennetts' ranch, did not differ between 1988 and 1989 sampling (Figure 2). The mean percent fines (particles 0.85 mm) was greater in 1989 (19.52) compared to 1988 (15.5%) values. This increase, however, was not significant ($P=0.35$). The sediment levels in lower Herd Creek were greater than values for sediment size-classes measured in 1988 for Big Boulder Creek (11%), a system less impacted by sub-surface fines (Richards et al. 1989).

Since construction on Big Boulder Creek and riparian rehabilitation measures on Herd Creek are scheduled to start in late summer of 1990, we intend to gather more extensive baseline physical measures in early summer of 1990. This inventory will include sub-surface core sampling above, in, and below the Big Boulder cutoff channel, as well as above and below the hydroelectric dam targeted for removal. Further, we will monitor sediment levels at the confluence of Big Boulder Creek and the East Fork. Measures of riffle surface substrate embeddedness (Burns 1984) will also be monitored in these areas. In Herd Creek, we will initiate a similar pre-treatment

Table 1. Flow (m^3/second) for each stratum of the East Fork of the Salmon River drainage, Idaho, September 1986, 1987, 1988 and 1989.

STRATUM	FLOW (m^3/second)			
	1986	1987	1988	1989
1	6.45	2.22	0.67	2.65
2 (Herd Creek)	0.94	0.47	0.28	0.60
3	4.60	2.12	0.89	2.60
4 (Big Boulder Cr)	0.91	0.46	0.19	0.50
5	2.81	2.70	NS	NS
6	2.21	NS	NS	1.00

NS = Not sampled

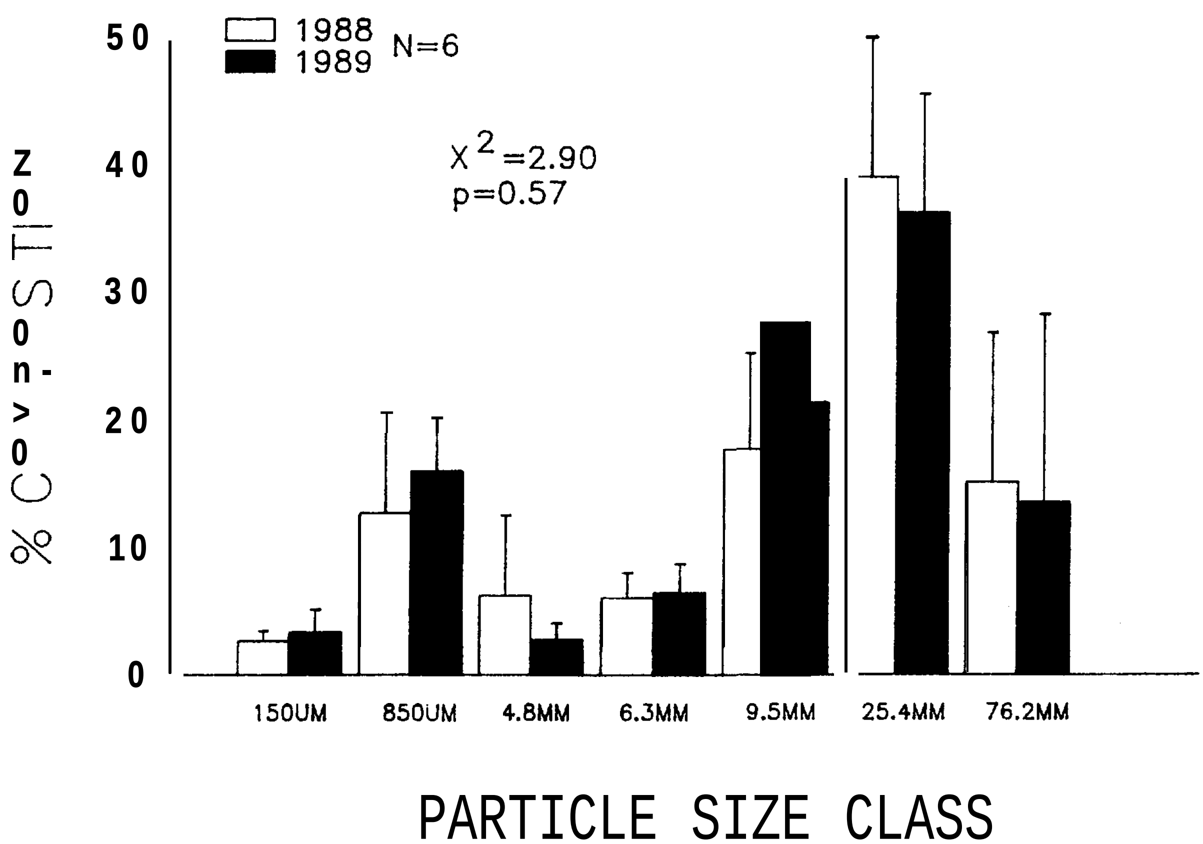

Figure 2. Core particle size distribution comparison between 1988 and 1989 in lower Herd Creek. Mean values are derived from six cores and error bars represent one standard deviation of the mean.

substrate monitoring plan. We also plan to start documenting streamside riparian cover following methods outlined in Platts et al. (1983).

Biological Evaluation

Total Salmonid Densities

Similar to 1988, mean total salmonid densities were low throughout the East Fork drainage except in localized regions (Figure 3). Herd Creek maintained the greatest mean total fish densities throughout the summer at 133.3 and 81.2 fish/100m^{2}pool in June and September, respectively. Stratum 6, the uppermost sections of the East Fork, also had a high mean total fish density in June (152.4 fish/100m^{2}pool), however, fish numbers did not persist over summer in this section (Figure 3). High early season densities in stratum 6 are primarily attributed to chinook salmon fry outplants in this region (per. comm. Phil Kunz, IDFG). Total fish densities in the two lowermost strata of the East Fork (strata 1 and 3) were generally low (10 fish/100m^{2}pool) but fairly consistent throughout the summer (Figure 3). As in 1988, Big Boulder Creek (stratum 4) had the lowest fish densities of all strata during both June and September sampling sessions. Individual fish densities (fish/100m^{2}pool) by species and age-class and associated analysis of variance (where applicable) of densities among strata are presented in Tables 2 and 3, respectively.

Age 0+ Chinook Salmon Densities

Densities of age 0+ chinook salmon did not differ between June and September sessions, however, numbers were generally greatest in June for all strata except stratum 1 (Figure 4). We did detect a significant difference in

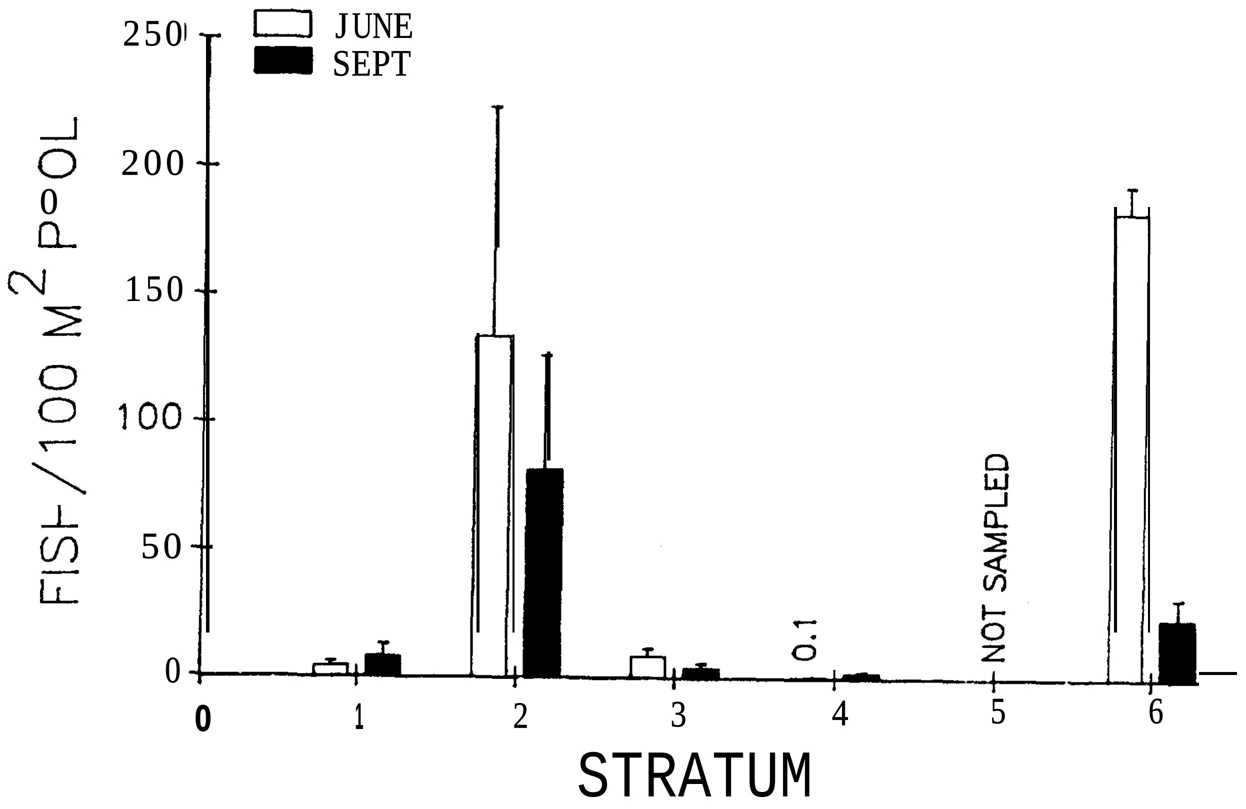

Figure 3. Mean total fish density by strata for June and September 1989, East Fork of the Salmon River. Error bars represent one standard deviation of the mean.

Table 2. Mean total fish densities (fish/100m^2pool) by session and stratum in the East Fork of the Salmon River, Idaho, 1989.

	Density by Species					
STRATUM	CHS YOY	STH YOY	STH 1+	WHF YOY	WHF AD	TOTALS
			Session 1			
1	1.4	0.4	0.2	0.0	2.4	4.4
2	128.9	0.4	3.5	0.0	0.5	133.3
3	4.2	1.0	1.2	0.0	2.0	8.4
4	0.0	0.0	0.1	0.0	0.0	0.1
5	NS	NS	NS	NS	NS	NS
6	179.0	0.0	1.2	0.0	1.2	182.4
			Session 2			
1	4.0	0.2	0.3	0.0	3.5	8.0
2	79.4	0.0	1.8	0.0	0.3	81.2
3	1.2	0.3	0.3	0.1	1.8	3.7
4	0.0	0.0	1.9	0.0	0.0	1.9
5	NS	NS	NS	NS	NS	NS
6	17.8	0.3	3.1	0.0	2.5	23.7

Table 3. Two-way analysis of variance for fish species by age class, East Fork of the Salmon River, 1989. The two non-metric independent variables were session and strata; fish density was the independent metric variable. An asterisk next to a probability indicates significance for that factor.

SPECIES BY AGE CLASS	SOURCE	DF	F VALUE	PROB.
Age 0+ Chinook	Stratum	4	5.6	0.001 *
	Session	1	2.1	0.158
	Session * Stratum	4	1.3	0.277
Age 0+ Steelhead	Stratum	4	3.0	0.028 *
	Session	1	2.0	0.160
	Session * Stratum	4	1.9	0.118
Age 1+ and older Steelhead	Stratum	3	2.4	0.044 *
	Session	1	0.2	0.633
	Session * Stratum	3	1.5	0.299
Whitefish Adults	Stratum	3	2.6	0.049 *
	Session	1	0.3	0.571
	Session * Stratum	3	0.2	0.923

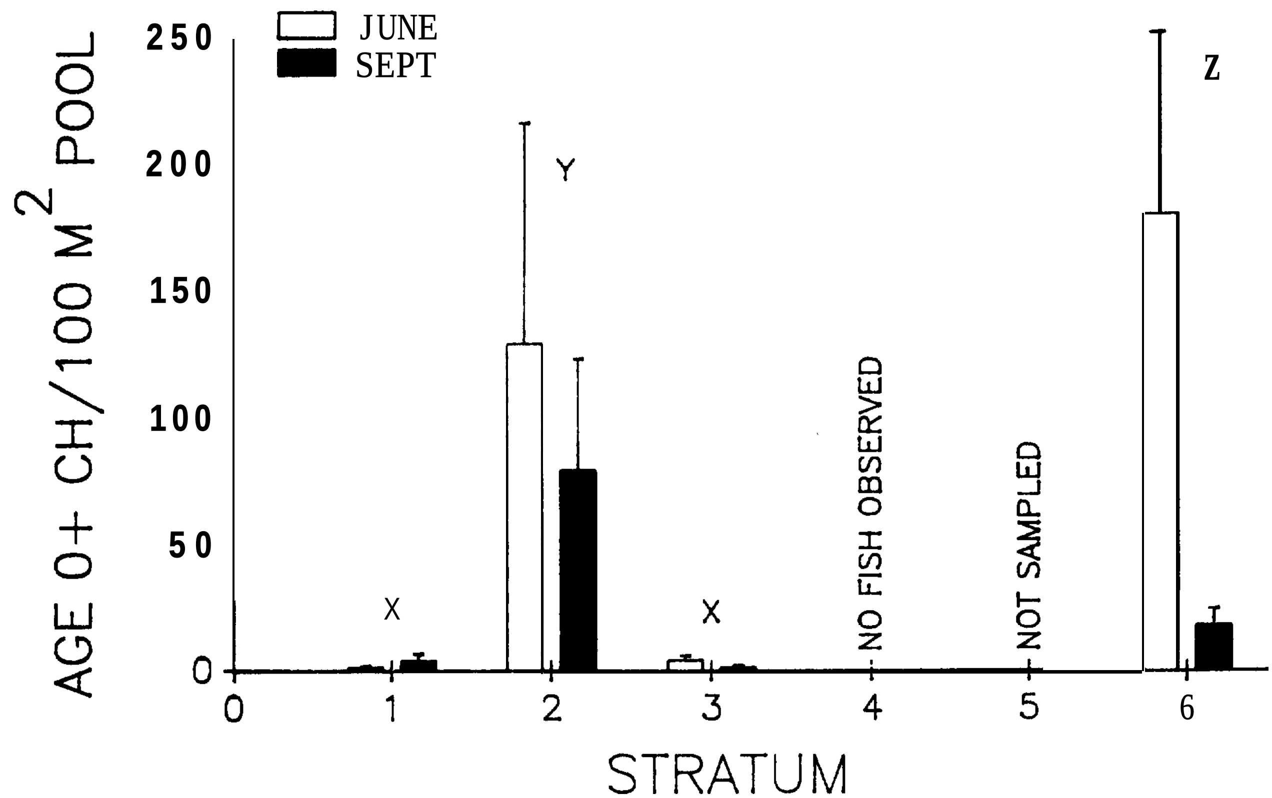

Figure 4. Density of age 0+ chinook salmon by strata (n=6 per stratum) for June and September 1989, East Fork of the Salmon River. A common letter indicates no significant ($P < 0.05$) difference between strata means with that letter. Error bars represent 95% confidence intervals of the mean.

chinook densities among strata (Table 3). Herd Creek (stratum 2) appears to be the most important salmon production area of the system as it maintained high densities through the summer; 129 and 79 chinook/100m^{2}pool in June and September, respectively. A similar pattern was noted in the summer of 1988 (Richards et al. 1989). Herd Creek's contribution to chinook production in the East Fork system is especially important since the stream is not supplemented with hatchery fish. The greatest overall chinook salmon density was recorded in stratum 6 during June at 179 chinook/100m^{2}pool. However, by mid-September salmon densities declined to a mean value of 18 chinook/100m^{2}pool. It appears that large numbers of hatchery outplanted chinook fry in this area had moved out before September. It is likely that these fish completely left the East Fork system, since chinook salmon densities in the two lower most strata (1 and 2) did not increase from the low observed densities in June (Figure 4). Finally, no chinook salmon were observed in Big Boulder Creek (stratum 4). An old hydroelectric dam on Big Boulder Creek (scheduled for removal in Fall 1990) serves as a barrier to upstream fish passage; this barrier precludes adult salmon from prime spawning habitat above the dam.

Age 0+ Chinook Salmon Lengths

We found chinook salmon lengths to differ among strata in June ($P < 0.01$) and in September ($P < 0.01$). Salmon lengths ranged from 32 to 100 mm in June and from 60 to 115 mm in September. In June, there was a distinct bimodal distribution of fish lengths; fish length distribution became unimodal by September (Figure 5), The June bimodal length distribution is attributed to the presence of naturally-produced fish and hatchery-supplemented fish. By

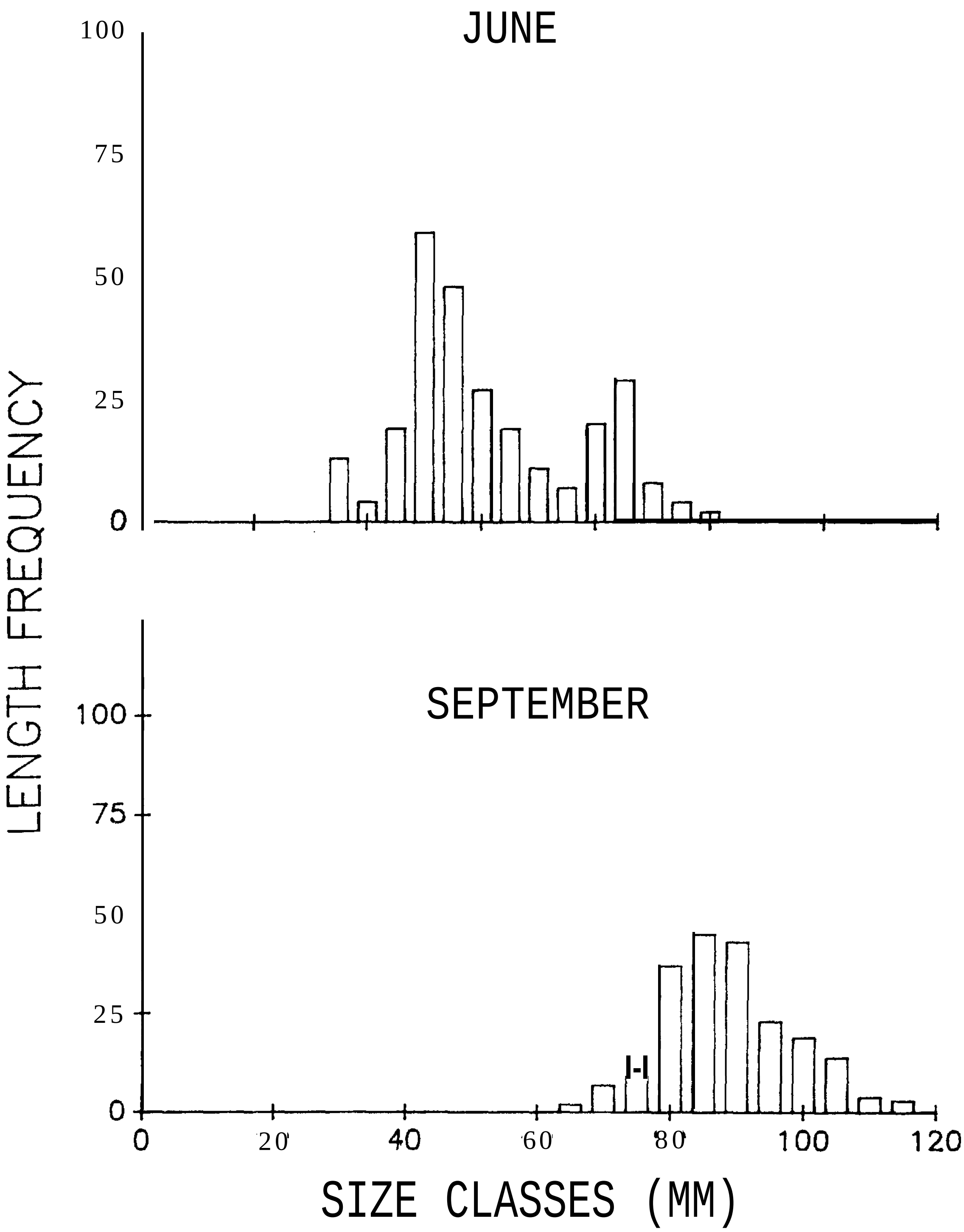

Figure 5. Length frequency histogram of age 0+ chinook salmon during June and September for all strata combined, East Fork of the Salmon River, 1989.

September, many of the larger outplanted fish had moved out of the system resulting in a unimodal distribution of fish lengths. In June and September, mean fish lengths were largest in stratum 6 at 72.9 and 95.0 mm, respectively and smallest in Herd Creek (stratum 2) at 49.0 and 79.9 mm, respectively. These mean length differences probably reflect the origin of the fish, primarily hatchery-outplanted versus naturally-produced.

Chinook Salmon Abundance and Kedds

Total numbers age 0+ chinook salmon varied considerably among strata and between months (Table 4). In June, we estimatea a total of 150,109 fish in strata 1 through 4 and stratum 6; most of this estimate was dominated by stratum b fish (101,071). Many of these fish were probably of hatchery origin. Because of the contagious distribution of fish within strata throughout the system, our 95% confidence intervals were large during both sessions.

Contributiou of fish from Herd Creek to total abundance increased greatly from June to September. Herd Creek represented less than 33% (45,630 fish) of our total abundance estimate in June (Table 4). These fish originated from the 58 redds counted throughout Herd Creek in 1988. By September, we estimated a total of 43,595 chinook salmon in the East Fork system; at this time, Herd Creek fish constituted 66% of this abundance estimate.

On the ground chinook salmon counts were done for Herd Creek in September. The number of chinook salmon redds counted on 15 September 1989 in Herd Creek, from the East Fork confluence up to just above East Pass Creek, totaled 14. This 1989 count is considerably less than the 1988 redci count (Table 5j. However, similar to 1988, 50% of the redds were counted above

Table 4. Estimate of chinook salmon abundance and 95% confidence interval in each strata of the East Fork Salmon River during June (session 1) and September (session 2), 1989.

STRATUM	Session 1 Abundance	Session 1 95% CI (±)	Session 2 Abundance	Session 2 95% CI (±)
1	1,276	2,440	3,828	12,697
2 (Herd Creek)	45,630	145,291	28,852	74,886
3	2,132	5,428	480	1,556
4 (Big Boulder)	No Chinook		No Chinook	
5	Not Sampled		Not Sampled	
6	101,071	276,111	10,435	18,171
Total	150,109		43,595	

Table 5. Distribution and abundance of redds counted in Herd Creek for 1988 and 1989.

AREA	KEDDS COUNTED		% OF TOTAL	
	1988	1989	1988	1989
Below Bennetts Ranch	16	3	27.6	21.4
Within Bennetts Ranch	13	4	22.4	28.6
Above Bennetts Ranch	29	7	50.0	50.0
Totals	58	14	100%	100%

Bennetts' ranch. This appears to be the most important spawning area of Herd Creek since spawning fish continued to **use** upstream areas despite few number of returning adults.

Other Salmonia Species Densities

Age 0+ Steelhead Trout. Densities of age 0+ steelhead trout differed significantly among strata but not between June and September sessions (Table 3). Densities of young-of-the-year steelhead were low in all strata relative to chinook salmon densities. In June, similar to 1988, strata 1 and 3 had the greatest densities at 0.4 and 1.0 age 0+ steelhead/100m^{2}pool, respectively (Figure 6). In September, densities ranged from 0.0 (strata 2 **and** 4) to 0.3 fish/100m^{2}pool (strata 3 and 6, respectively). We did not observe age 0+ steelhead trout in Big Boulder Creek during either session. Consistent with 1988 **data** (Richards et al. 1989), stratum 3 maintained the highest age 0+ steelhead densities throughout the summer (Figure 6).

Age 1+ Steelhead Trout, Densities of age 1+ steelhead trout differed among strata but not between sessions (Table 3). Densities ranged from 0.1 to 3.5 fish/100m^{2}pool in June, and from 0.3 to 3.1 fish/100m^{2}pool in session 2 (Table 2). Strata 2 (Herd Creek) and 6 maintained the highest densities throughout the summer and were responsible for the statistical ciifference among strata (Figure 7j.

Age 0+ Whitefish. We observed very few age 0+ whitefish during both sesions (Table 2). These few fish were observed in stratum 3 in September.

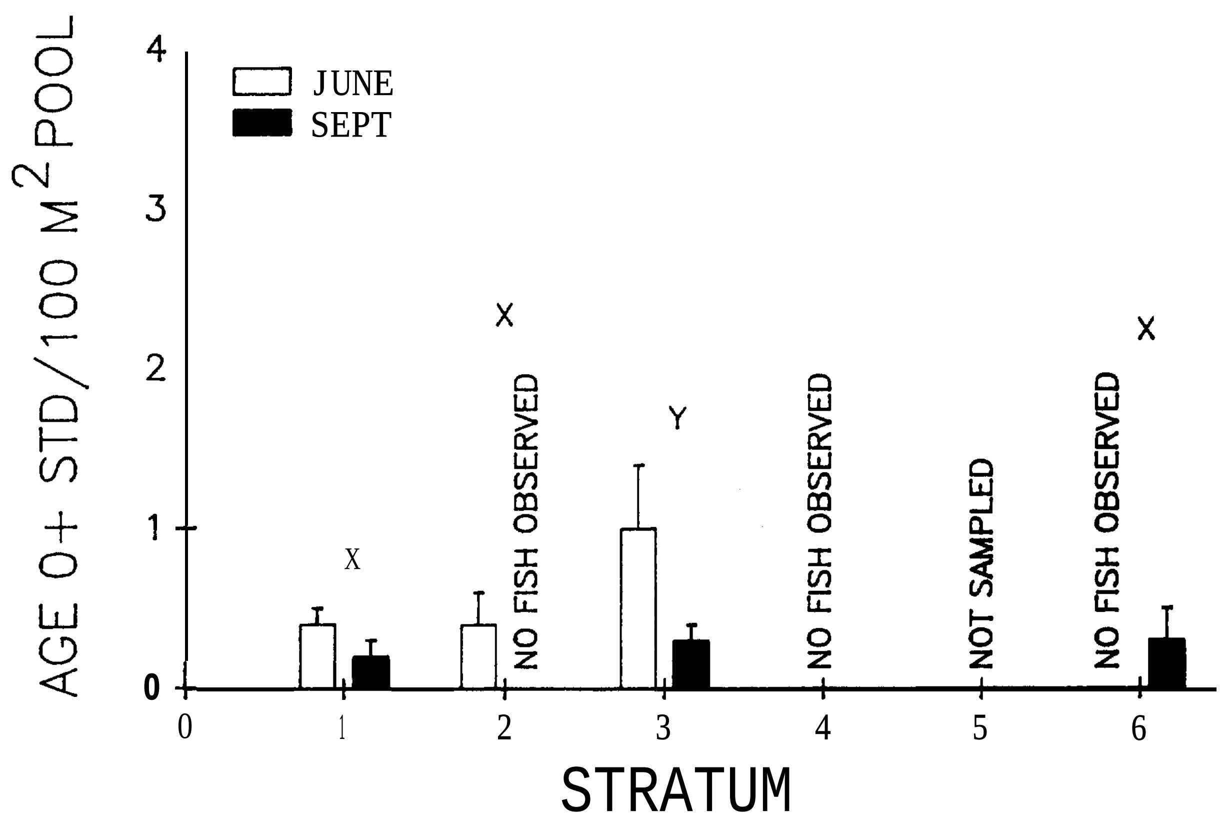

Figure 6. Density of age 0+ steelhead trout by strata (n-6 per strata) for June and September 1989, East Fork of the Salmon River. A common letter indicates no significant ($P<$ 0.05) difference between strata means with that letter. Error bars represent 95% confidence intervals of the mean.

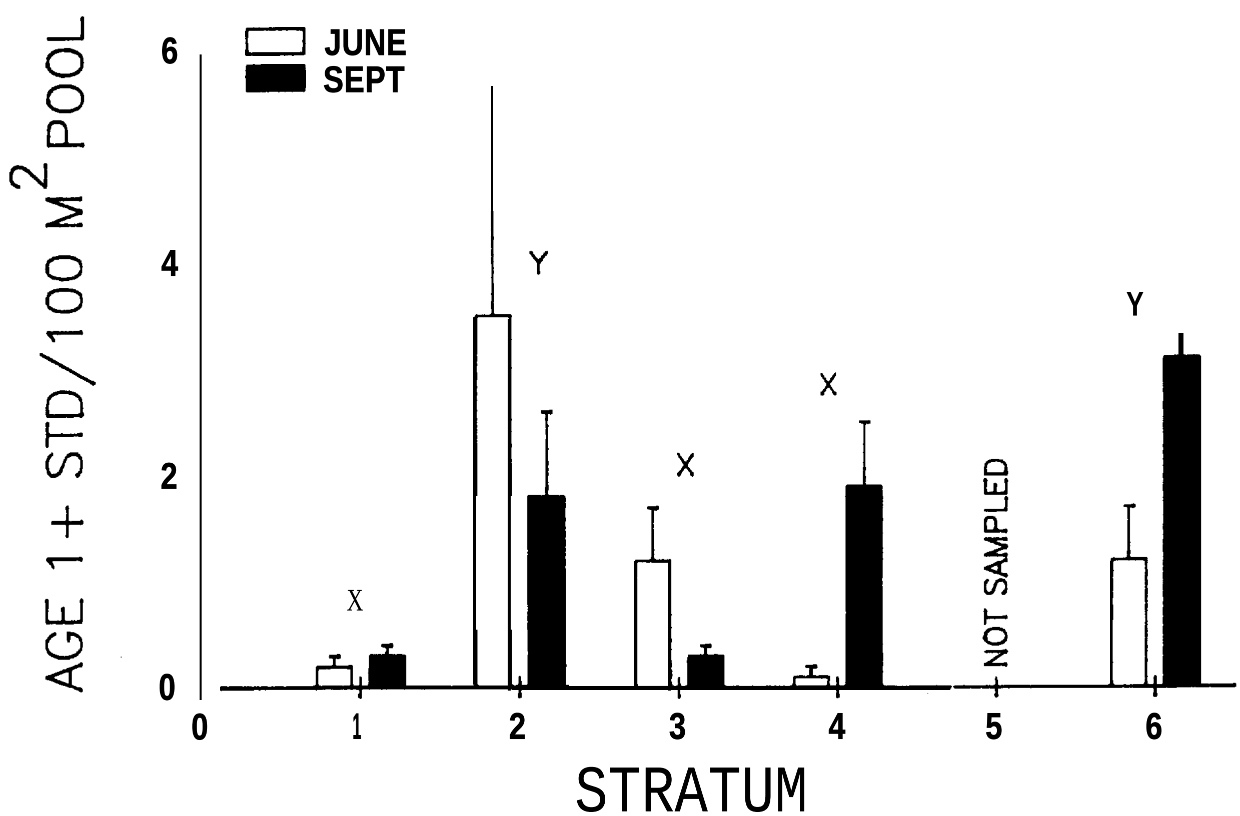

Figure 7. Density of age 1+ and older steelhead by strata (n=6 per strata) for June and September 1989, East Fork of the Salmon River. A common letter indicates no significant ($P < 0.05$) difference between strata means with that letter. Error bars represent 95% confidence Intervals of the mean.

Age 1+ and Older Whitefish. Adult whitefish densities were greatest in the East Fork proper strata (1, 3, and 6 j during both sessions (Figure 8). Of the two tributaries sampled, only Herd Creek contained whitefish adults; however, densities in this stratum were significantly less than in strata 1, 3, and 6. We detected no difference in whitefish adult densities between June and September (Table 3). Densities ranged from 0.0 to 2.4 whitefish/$100m^2$pool in June, and from 0.0 to 3.4 fish/$100m^2$pool in September. The highest densities of whitefish adults in both sessions were in stratum 1 (Figure 8). This section of stream is characterized by deep pools, habitat that whitefish adults frequently reside (Simpson and Wallace 1978j.

Relative Abundance

Age 0+ chinook salmon dominated the fish community in strata 2 and 6 during June (Figure 9a). Chinook salmon constituted 95% of the total fish community in Herd Creek (stratum 2), but were completely absent in Big Boulder Creek (stratum 4) where rainbow/steelhead and cutthroat trout dominated. Of the main East Fork strata, stratum 6 was most dominated by chinook salmon, while strata 1 and 3 had a more equitable distribution of species.

In September, chinook salmon continued to dominate community composition in strata 2 and 6; they were also proportionally more abundant in stratum 1 compared to the June session (Figure 9b). Whitefish relative abundance was greatest in strata 1 and 3. Rainbow/steelhead abundance increased in Big Boulder Creek (stratum 4) in September, probably resulting from downstream movement of fish from up-drainage high mountain lakes.

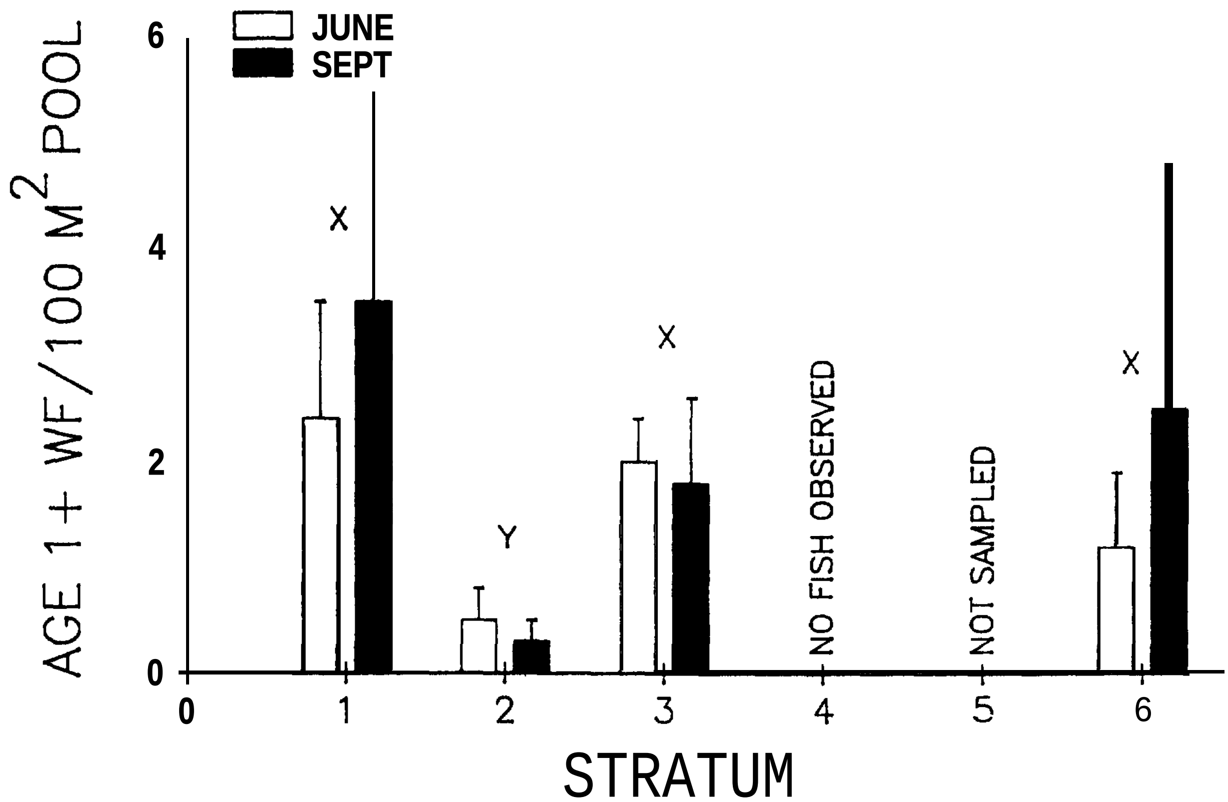

Figure 8. Density of age 1+ and older whitefish by strata (n=6 per strata) for June and September. A common letter indicates no significant ($P < 0.05$) difference between strata means with that letter. Error bars represent 95% confidence intervals of the mean.

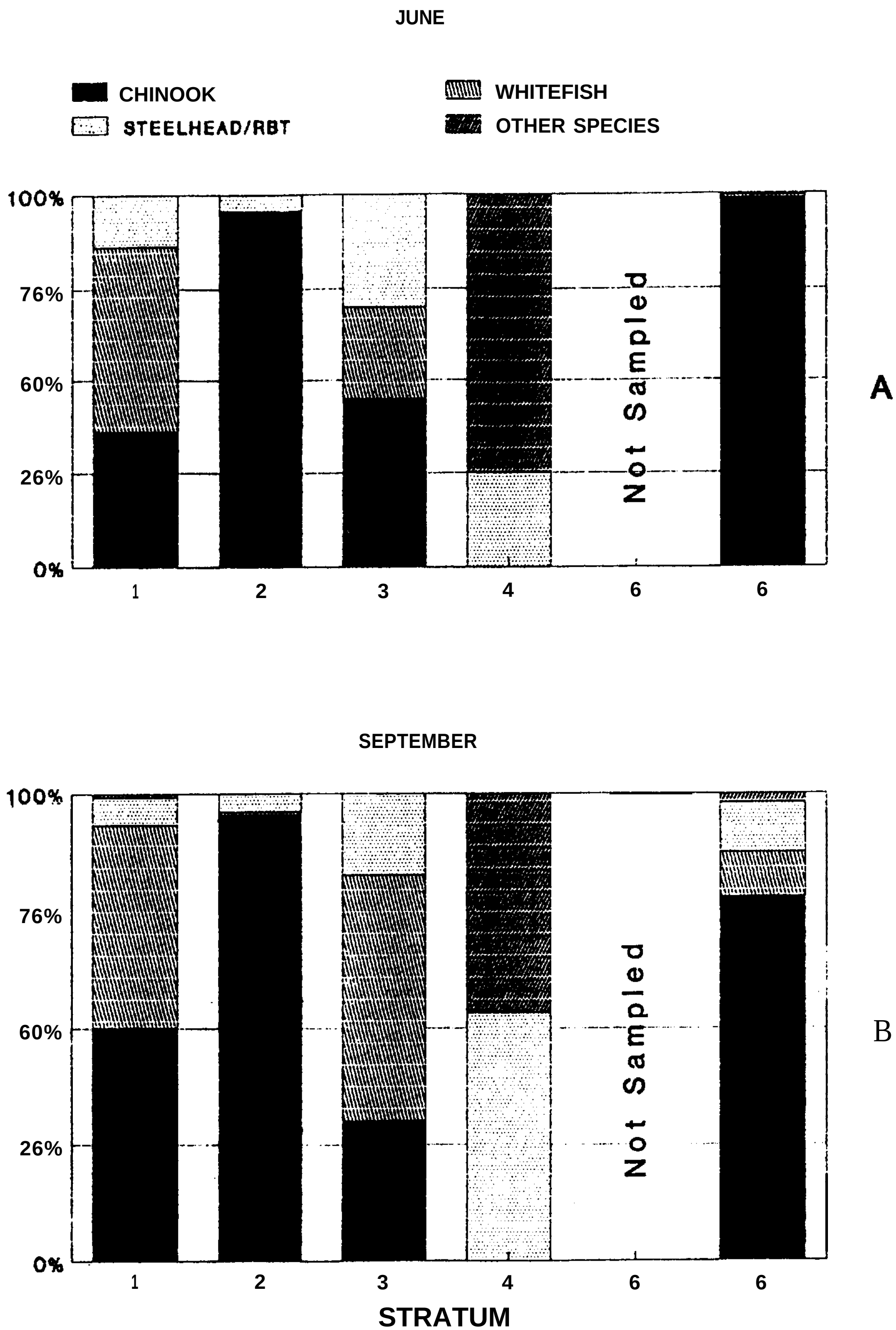

Figure 9. Relative abundance of fish species by strata in June and September 1989, East Fork of the Salmon River. Other species Include bull and cutthroat trout.

SUMMARY

In conclusion, Herd Creek (stratum 2) and the upper East Fork (stratum 6) contributea most to production of age U+ chinook salmon within the East Fork system. Herd Creek appears to be the major contributor of naturally-produced fish in the system. Proposed riparian rehabilitation and protection measures for Herd Creek will help to further insure the integrity of this run. Other sections of the East Fork contributed little to chinook salmon production. Further, we did not document anadromous fish use in Big Boulder Creek. The removal of the old hydroelecric dam, however, will give anadromous fish access to excellent spawning gravels upstream.

Fish monitoring in 1990 will continue as in the past with several modifications. First, we will document fish numbers in riffle, as well as pool habitat to produce density estimates that will be comparable to estimates generated by other agencies. In stratum 5, stream access via private property has become difficult in the last couple of years. If this continues to be a problem, we will select new sites where access is ensured. This will allow us to gain a more complete assessment of fish production in mid-reaches of the East Fork Salmon River.

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